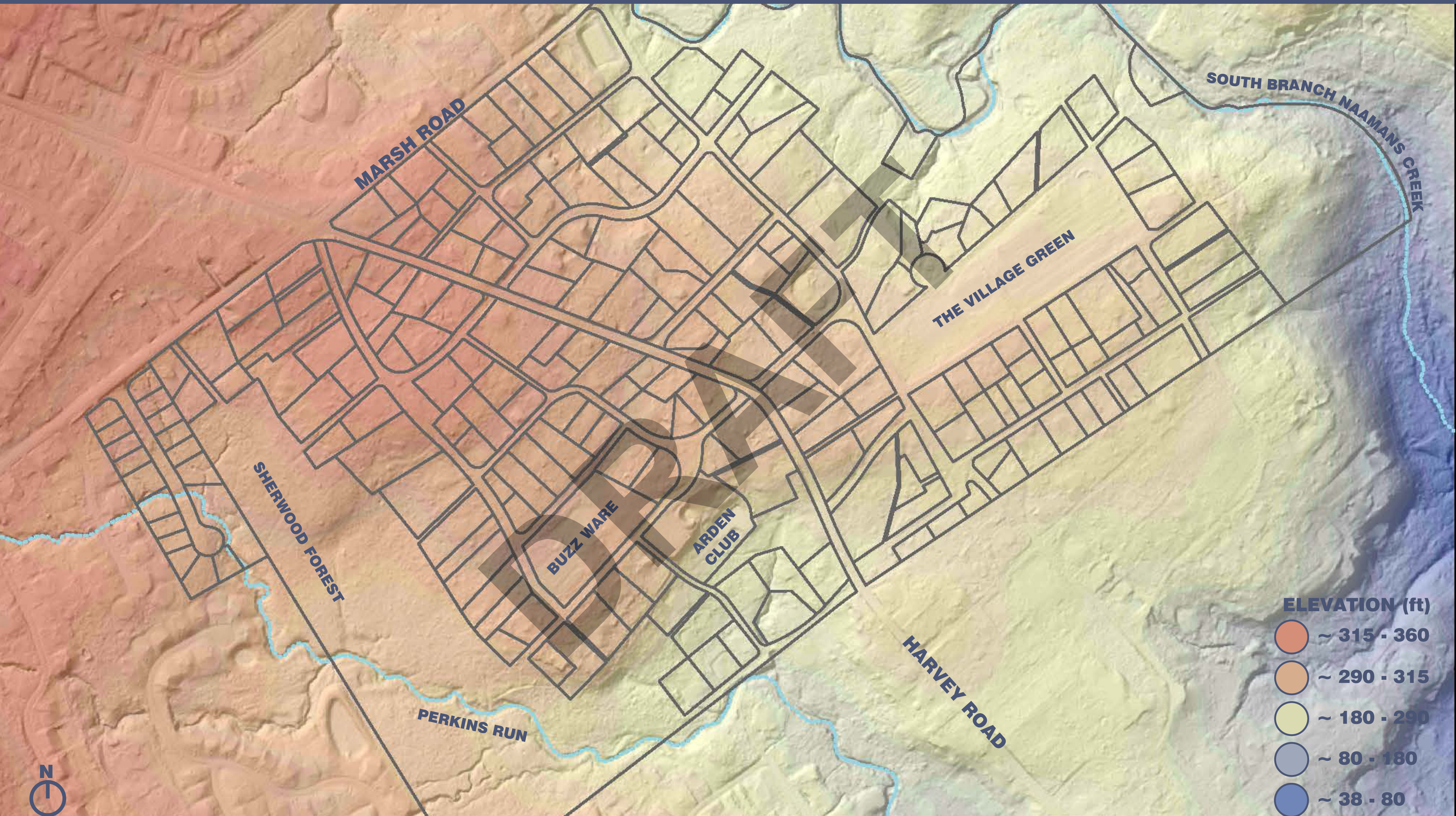
WATER QUALITY MASTER PLAN



THE VILLAGE OF ARDEN, DELAWARE

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LIST OF COMMON ABBREVIATIONS & TERMINOLOGY

ac. - Acre
sf. - Square foot
cu. ft. - Cubic feet
BMP - Best management practice
DelDOT - Delaware Department of Transportation
DNREC Delaware Department of Natural Resources and Environmental Control
EPA Environmental Protection Agency
GIS Geographic Information System
NCC New Castle County
USACE United States Army Corps of Engineers
Proprietary Practice - a BMP designed by a professional
Effective Impervious - the area of impervious surface not treated for water quality by a stormwater management system. Areas of impervious surfaces that are treated by a stormwater management system are subtracted from the overall impervious area to derive the net area of effective impervious surfaces. The amount of effective impervious area is a key indicator of pollutant loads, generally the higher the percent effective impervious within a watershed, the greater the impairments due to stormwater runoff.
Water Quality Event - the rain event defined by New Castle County (NCC) to meet water quality standards; NCC provides numerical values for design storm events the water quality event defined as the 6 month event, i.e. 200% chance of happening in a given year and is measured at 2”.
Crowned - a term used in road topography to describe a highpoint at the center of the road with slopes down to each side or shoulder.

This report was prepared on behalf of The Village of Arden by ForeSite Associates Inc. using matching funds awarded to the Village of Arden through the Delaware Department of Natural Resources and Environmental Control's Surface Water Matching Planning Grant program. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of Department of Natural Resources and Environmental Control.

The majority of roadway drainage in the Village of Arden runs unmanaged in the upper elevations of the watershed, down roadway gutters, to the lower elevations in the watershed; in these lower areas storm flows drop into catch basins that outfall directly into the neighboring forests to the downstream waterbodies of Perkins Run or Naamans Creek. The rich forested landscapes found throughout the Village aide in mitigating water quality however this document seeks to disconnect the outdated drainage strategy and provide recommendations to balance the hydrology with best practices and green infrastructure initiatives that treat and manage stormwater runoff.

1 INTRODUCTION

1.1 BACKGROUND AND PURPOSE

This document is the third in a series of partnerships between the Village of Arden (Arden) and ForeSite Associates Inc. (ForeSite) In 2015 and 2017 Arden leveraged settlement monies to repair the eroded stream channel that developed from an outfall in the neighboring development of Buckingham Green into Sherwood Forest. After completion of that project, Arden looked to continue their stewardship of the Arden landscape and determine what else they could do to improve water quality throughout lands of Arden. There were other obvious areas where stream erosion was occurring and the village knew these were areas of opportunities, but what was causing the erosion and how could Arden do more than repair but be proactive in prevention and better manage stormwater runoff? They decided to seek a second Surface Water Matching Planning Grant to develop an Arden wide Water Quality Master Plan.

This master plan would provide a long term plan of intervention to identify areas of immediate need or opportunities and areas for future consideration, to better manage flows through Arden and reduce the impact of stormwater run-off to the natural lands that border Arden. This document is not intended to be a drainage plan however the hydrologic phenomenons that govern stormwater runoff, are directly effected by good or poor drainage patterns within a watershed. Often the two are so intertwined in our peri-urban landscapes it is difficult to provide recommendations for one, without an understanding of the other. With all of the developed lands implemented when there was little understanding of stormwater management, this is the scenario within Arden. A landscape where concrete and drainage infrastructure directs water to the bottom of the watershed, directly to the adjacent creeks, provides rapid drainage to the impervious areas but typically results in ecological damage at the point of discharge in natural areas. To provide a comprehensive master plan this document creates water quality opportunities by understanding and responding to the drainage patterns within the landscape, both natural and created.

The purpose of this master plan is to identify areas within the Village of Arden that may be feasible to implement stormwater Best Management Practices (BMPs) to treat the 2” water quality storm event. The implementation of these facilities will provide water quality treatment for the impervious lands within Arden. At a conceptual level of analysis this document:

- Identifies broad scale drainage patterns through Arden lands using publicly available data
- Determines feasible areas for implementation of stormwater BMPs
- Evaluates the potential of the proposed BMPs
- Differentiates the BMPs by subjective criteria to aid in implementation hierarchy

1.2 WHY A MASTER PLAN

All creatures require some form of shelter for survival. We has humans have been creating structures in some form as far as human history can be accurately traced. Every time a drop of rain falls from the sky to the ground it takes a down gradient path through the landscape to join streams, rivers, and ultimately the ocean. Structures and other impervious surfaces created by humans, alter the natural path of rainfall through the landscape. In recent decades we has come to an understanding that the magnitude of impervious coverage we have created is negatively effecting the surrounding natural landscapes. Some of these impairments include increased flooding, unstable topography, and chemical and biological imbalances. These problems exist on a watershed basis. As defined by Merriam-Webster a watershed is “a region or area bounded peripherally by a divide and draining ultimately to a particular watercourse or body of water”. Watersheds can be defined by any boundary, and can be as small as one family’s property, or as large as the Mississippi River. The properties of that watershed define the impairments present and are often most expressive at the down gradient areas of the watershed, such as in the polluted waters of the Mississippi River Delta. What scientists and researchers have difficulties conveying to the layperson is that every drop of water in a watershed counts and even though impairments are most visible to the human eye in the downstream locations, upstream landscapes are directly connected even if the connection isn’t visible on the surface. Albeit an exaggerated comparison, the watershed for the Village of Arden follows the same principles as the Mississippi River and its Delta, rainfall upstream is equally responsible for impairments downstream.

Being built long before stormwater management was required, the lands of Arden illustrate typical drainage patterns and infrastructure of its time. Much of the upper watershed is void of infrastructure, or concrete gutters have been installed to quickly transport rainfall away from infrastructure and into the stream corridors in the lower elevations of the landscape. Water damage to infrastructure can be costly, thus the theory to shunt water as fast as possible away from it, made sense years ago. This is an important relationship to understand within human dominated landscapes. The ‘good drainage’ that clears water from our roads, roofs, and yards is at a significant cost to the broader ecosystem we live in. In many ways, good drainage, particularly old systems focused on removing water as fast as possible, are at odds with stormwater management and clean water in our streams. What is not regularly understood, because it isn’t visible, is that when water rushes over roofs and roads, tiny particles from petrochemicals and metals to dirt are transported across the landscape, small organic and in-organic compounds that change the chemical properties of the rainfall as it moves downstream. The EPA has developed tolerances for waterways for these compounds and defines them as TMDLs or Total Maximum Daily Loads. Types of measured TMDLs include levels of nitrogen, phosphorus, bacteria, and TSS or total suspend solids. One of the most common types of TSS found in Arden is sediment; this sediment can be in the form of dirt on roadways, gravel from driveways, and erosion of forest soil in the woodlands. Erosion of forest soil is where this discussion all ties together in Arden, and why every drop of rainfall counts. Drainage infrastructure that aims to carry water downhill as fast as possible, enters the woodlands at a different speed than it would if it were just overland flow. This unbalanced speed erodes the forest and releases sediment into the waterway. Fixing the impairment at the stream can be costly and it does not address the root of the problem. Slowing the water higher up in the watershed, reduces the force at which the water enters the woods, in turn reducing soil erosion and the amount of sediments causing downstream water quality impairments. These flows also bring dangerous flooding with them to downstream populations. Just as the runoff from developments upstream bring uncontrolled flows through Arden’s section of Naamans Creek, Arden’s runoff adds to the flows heading through communities downstream of it. This scenario is why this plan is as much a water quality plan as it is a drainage plan, the two are directly linked within the lands of Arden. A simple example of this downhill phenomenon is Little Lane. Based on the site visits and discussions, stormwater does not appear to be an issue for residence along this road. During rain events the run-off makes its way downhill and down Little Lane to Miller’s Road. At this intersection the runoff flows into two catch basins that connect underground and pipe water under Miller’s Road to outfall into leaseholder land and then the woods on the other side. An erosive gully has developed through the woods down to Naamans Creek. Ever time it rains more soil is eroded from the channel and more sediments introduced into the creek. Restoration of the channel will aid in stopping the immediate erosion but it doesn't solve the cause of the problem, the amount of water entering the catch basins. Rain barrels, porous paving, and any number of water catchment amenities implemented on leaseholder lands within this watershed, will reduce the amount of water entering the drainage network and help in restoring the stream course. There are many engineering nuances skipped in this example for simplicity in explanation, but the outcome is the same, every drop of water slowed down higher up in the watershed, will aid in preventing downstream degradation.

A master plan document does not look at a singular place or problem area, but an area at a large scale, in this instance the Arden watershed scale. By analyzing the entire watershed, it is able to delineate opportunities for water quality where they will be most effective. Since drainage and water quality are inherently linked in the design of Arden, it is likely these water quality initiatives will have a beneficial effect on over-burdened drainage systems downstream.

1.3 THE MASTER PLAN APPROACH

This document is organized by scale, with each section identifying water quality frameworks appropriate to the area of focus. There are three primary sections, the Arden scale analysis, the Sub-watershed analysis and then the Master Plan, which is further delineated by common land opportunities and leaseholder opportunities. The Arden scale analysis identifies facets of the watershed by the bounding areas of the Village of Arden. This section also reviews the larger watershed context and how the lands of Arden are identified within EPA and other regulatory frameworks. Moving to a smaller scale, the Sub-watershed analysis explains the early analysis done for this report and answers questions such as how is water moving through the Arden landscape. The final section of the analysis scales the gathered information down to site specific BMP interventions, as well as explaining BMP interventions for which leaseholders can implement with minimal design needs.

The master plan project was approved by DNREC and the Village of Arden in early 2020, just as a worldwide pandemic began to accelerate in our area. With the majority of mapping information relying on a desktop analysis, production was only slightly delayed in efforts to review the analysis on-site. The primary steps to preparing the information within this document, which are included within the sections of this plan, include:

- Gathering of publicly available data and the preparation of a base map
- A broad watershed desktop analysis of hydrology and flow patterns within the limits of Arden
- Comparison of the desktop analysis with the existing drainage infrastructure
- Site visits to view elements of the desktop analysis
- Analysis of findings
- Preparation of recommendations

Each section on its own contains a narrative of water quality within the Village of Arden and could be read independent of other sections. This is especially true in the case of section four which can be used as a manual of specific BMPs. However, the document in its entirety is critical to the understanding of how the recommendations in the final section were determined. An understanding of all pieces of the master plan will allow Arden to fully evaluate the recommendations within this plan and also adapt the strategies presented to future changes in the watershed. Water is an active element that is constantly changing our landscapes, this plan provides recommendations for the conditions and knowledge base that were understood at the time of plan preparation. There is the potential that some of these recommendations may not be as effective if landscape conditions change, either through intentional or unintentional modifications within the watersheds, or if new knowledge on water quality treatment becomes available. Understanding the rationals and broader context, provided by this plan in its entirety, will allow the residents of Arden to adapt recommendations or develop new strategies should landscape conditions vary from those presented by this plan.

2 ARDEN SCALE ANALYSIS

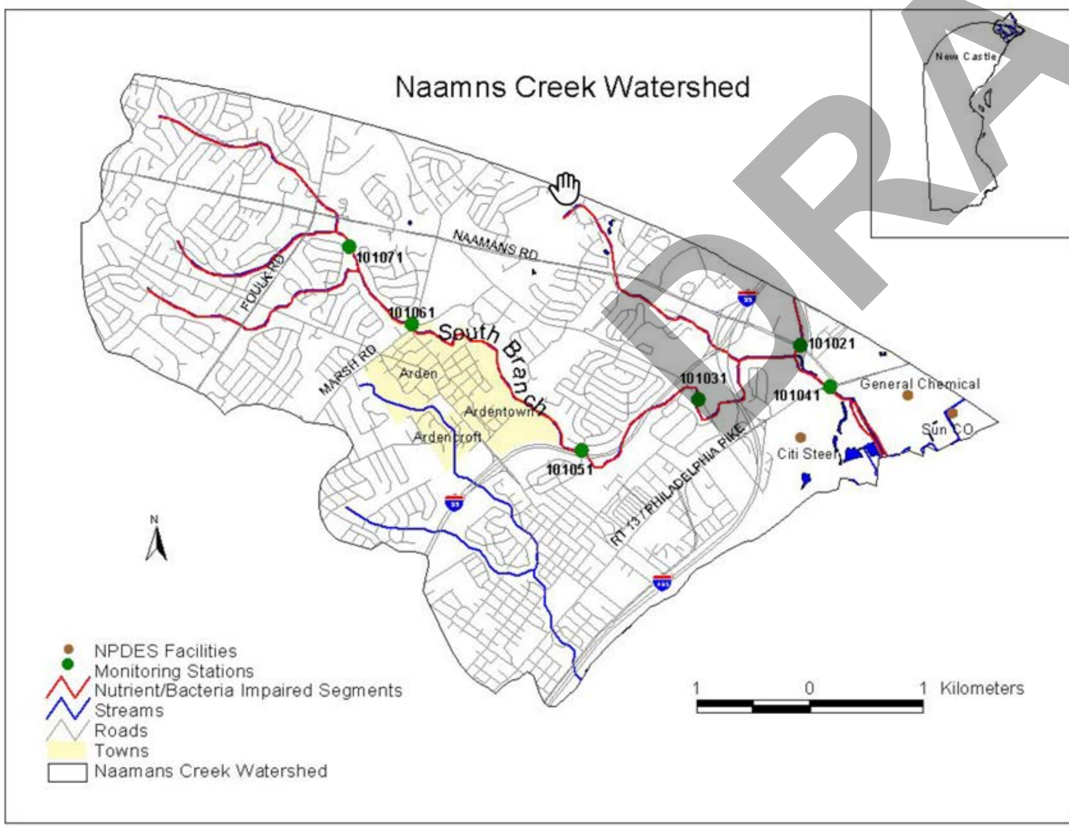
2.1 MAJOR WATERSHEDS AND TMDL STATUS

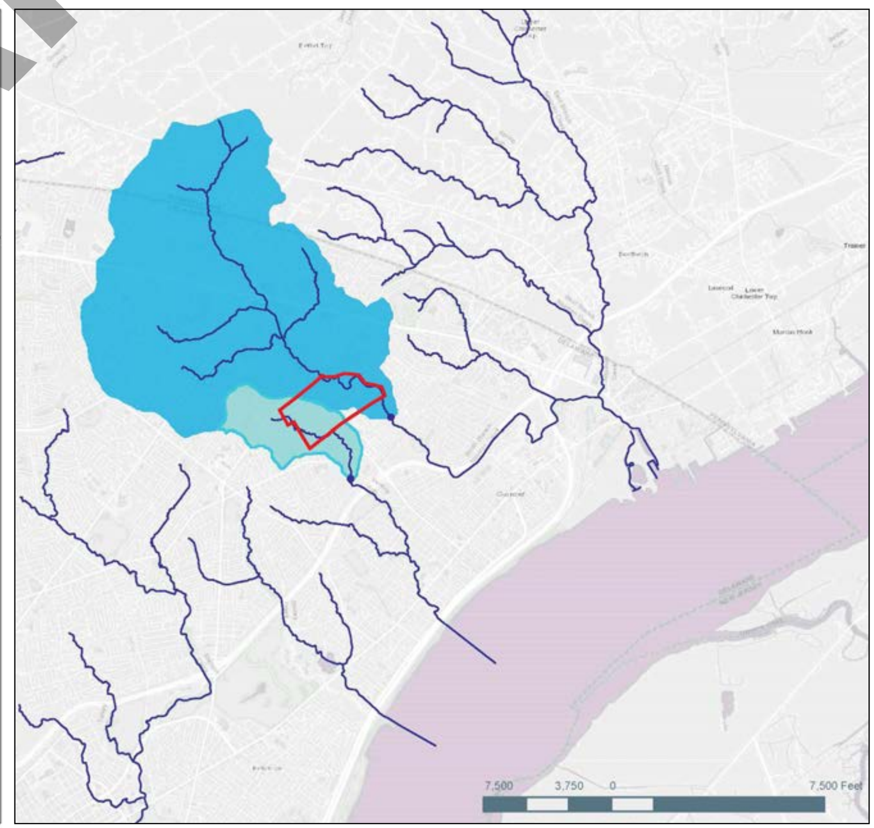
The Clean Water Act is the governing regulation that initiated the majority of water quality monitoring across the US. There are many levels and nuances in the coordination between government entities to ensure the regulations are met. Given the focus of this plan is the broad scale analysis of Arden, the following narrative is a succinct summary of the greater connections to the Clean Water Act and some details have been omitted for clarity. When water drains from a roadway, roof, or any other impervious surface it either runs over land to a natural water-body or is connected through structures to a natural water-body. That system of structures either does or does not connect to the sanitary sewer system; if it does, it is known as a combined sewer system or CSO system, if it does not, it is known as an MS4 or Municipal Separate Storm Sewer System. MS4 systems connected to urbanized or densely populated incorporated areas are required by the EPA to enter the MS4 program. Every MS4 must request a permit from the EPA to discharge their stormwater system into Waters of the US, i.e. the natural water-bodies. These permits use TMDL and other water quality monitoring to set the limits of pollutant loading to a receiving water-body. In many urban areas the current discharges exceed permit allowances and municipalities are seeking ways to reduce effective impervious, the impervious area directly connected to the drainage system or water-body. The Village of Arden does have an MS4 system but the population size of the municipality, as of now, is not required to enter into the EPA MS4 program. The concepts provided in this plan do seek the same ultimate goals, improve the community's interaction with stormwater runoff and to reduce water quality impairments through the reduction of effective impervious to a natural water-body. In the future, should Arden be required to enter an MS4 program, this plan and any implemented best management practices would likely be applied to any permits required. This succinct narrative is included to explain the direct connection between State level watershed analysis and monitoring of impaired stream corridors to the mandated implementation of stormwater best management practices.

The establishment of TMDL limits to determine a water-bodies level of impairment from impervious surface and other pollutants is delineated by watersheds. Like this plan, the limits of these boundaries are divided by scale. At the highest level Delaware is part of the EPA Region 3, which includes Delaware, District of Columbia, Maryland, Pennsylvania, Virginia, West Virginia, and the associated tribal lands within these areas. Zooming into the State scale, Arden is part of the Piedmont Watershed area, specifically the Naamans Creek watershed, which covers ares in both Pennsylvania and Delaware and drain to the Delaware Bay. The Naamans Creek watershed is further delineated by the stream courses that run through the majority of each state, creating the North and South branches of the Naamans Creek Watershed. The South Branch is adjacent to the lands of Arden. This is the limit of delineation at the State level. The majority of reports on TMDL pollutant impairment are limited to this level. Provided in the appendices are reports for these watersheds. The reports were generated for submission to the EPA as updates on pollutant mitigation. A map from one of these reports is illustrated on the adjacent page. As the residents of Arden are probably aware, they are adjacent to two perennial streams, not just the South Branch of Naamans Creek. This second stream is shown in the State watershed map, and although it doesn't show a hydrologic connection to Naamans Creek, it is included within the same watershed. Known as Perkins Run, its drainage area is likely too small for evaluation at the State scale and thus it is included within the larger Naamans Creek watershed. Perkins Run is not considered an impaired waterway by the State and/or has not been reviewed, and thus has no reporting. The South Branch has been evaluated and is considered impaired by high levels of bacteria and elevated levels of the nutrients nitrogen and phosphorous; the watershed health is also compromised by loss of habitat and biological diversity. The monitoring stations are located prior to entering the lands of Arden and further South past the lands of Ardentown. The State and County are addressing bacteria issues primarily through improvements in sanitary sewer infrastructure and treatment as well as strategies to reduce pet waste in the landscape.

To refine the State scale further and determine the likely watershed boundary of Perkins Run adjacent to the lands of Arden, this report generated the map shown next to the State map on the adjacent page. Using a publicly available analysis program provided by the USGS, a point on each stream connected to the Village of Arden was evaluated for its watershed boundaries. The reports generated with each analysis can be found in the appendices. As anticipated both watersheds include lands outside of Arden. The map illustrates the limits of Arden in a red box and the local watershed to Naamans Creek in bright blue and the local watershed to Perkins Run in aqua blue.

Researching existing reports are a critical step in the data gathering process. Given the expansive scale of the State data and the minimal refinement using publicly available analysis tools, the findings were as expected and further explorations at a finer scale were required to understand more about the Arden watersheds.





2.2 EVALUATING THE WATERSHED

The prior section illustrated the large scales often used to differentiate water quality impairments for an entire state. Like many other states, the monitoring and evaluations continue at local levels of government, in the case of Delaware at the County level. New Castle County (NCC) is the most populated County within DE, with several MS4 municipalities that meet the EPA's population thresholds do require a permit. The first steps taken to begin to meet the EPA permit thresholds required the County to develop a Stormwater Pollution Prevention and Management Program; to accomplish this they partnered with DelDOT and several smaller municipalities that met the MS4 population thresholds. The second phase of the permit was to build on this first phase and develop priority watersheds to implement Restoration and Preservation strategies. The eight watersheds were ranked by various criteria including bacteria loading, nutrient loading, and impervious cover. The Christina River watershed scored the highest on restoration evaluation and the Dragon Run watershed the highest on the preservation evaluation. The active phase of the permit is the development and implementation of a water quality improvement plan. The County used local data and references, such as the Maryland Watershed Implementation Plan, to complete the recommendations. Several references to these documents are provided in the appendices.

The narrative of the County scale evaluation concentrated on a 3% reduction in effective impervious surfaces to reduce water quality impairments. These reductions were based on evaluations of TMDLs and monitoring data. The monitoring data available was not limited to Arden only, and without doing costly and time consuming detailed studies, this report had to determine a method for evaluating effective impervious reductions within the comparably much smaller Arden watersheds. This report strongly supports monitoring and TMDL evaluations within the watershed to refine the available data, but also acknowledges the multiple opportunities that can more immediately help water quality impairments without additional studies. This Master Plan uses the Impervious Cover (IC) methodology as developed and tested by the Connecticut Department of Environmental Protection (CTDEP), and outlined in the article 'Responding to the First Impervious Cover–based TMDL in the Nation', Arnold et al., and included in the appendices. The CTDEP conducted a study of streams in the area and came to the conclusion there was a direct relationship between impaired streams connected to watersheds with impervious cover higher than 11%-12%. This analysis was then tested within the watershed of the University of Connecticut. To be conservative, the limit of 11% impervious was utilized. The on-going project looks to reduce effective impervious through the use of BMPs and other methodologies to make a watershed function as though it has only 11% impervious. Additional research into the IC method provided variants to apply the IC TMDL method to more urbanized areas. Given the age of the Arden community landscape and the significant amount of mature tree cover, compared to surrounding locations, the use of a general 11% IC was determined to be a feasible percentage to evaluate and compare the watersheds within the Village of Arden.

Arnold, C., Bellucci, C., Collins, K., & Claytor, R. (2010, October 1). Responding to the First Impervious Cover–based TMDL in the Nation (K. Cappiella & N. Law, Eds.) [Review of Responding to the First Impervious Cover–based TMDL in the Nation]. Center for Watershed Protection; Journal of the Association of Watershed & Stormwater Professionals. https://owl.cwp.org/mdocs-posts/arnold-et-al-2010-ic-tmdl/

2.3 DESKTOP ANALYSIS

Impervious Cover

Impervious cover in relation to stormwater is characterized by any surface that prevents the infiltration of rain water into the soil, such as roofs, roads, sidewalks, parking areas, driveways and patios. As an analysis feature, impervious cover is often delineated through the processing and characterization of aerial imaging. To achieve a finer scale for this plan, DE GIS data was augmented with computer aided design software (CAD) to create an impervious map of Arden. Arden has two major roads that extend beyond the Arden limits, Harvey Road and Marsh Road, all other roads are internal to Arden. There are three parking lots and two primary community buildings. The community buildings along with the paved recreation areas, internal roads, individual driveways and leaseholder residences, combine to create an area of roughly 27 acres of impervious surfaces, or approximately 16.5% of the landscape within the Village of Arden. These impervious surfaces shunt water directly or indirectly to a drainage network of catch basins, pipes and open swales, to either Perkins Run or Naamans Creek.

Federal Emergency Management Agency (FEMA)

Stormwater is less effective in areas that are flood prone and have higher water saturation in the soil. This map on the following page illustrates existing wetlands and areas identified as flood prone by FEMA mapping. These maps often have similar patterns to that of soil properties, particularly the hydrologic soil groups featured in this plan. Of Arden's two waterways, only Naamans Creek has publicly available data mapping flooding and wetland typologies. The mapping legend is that provided by FEMA, with the below narrative for further understanding:

A - this type of flood zone is not present within Arden

AE - this is the 1% annual flood line, formally commonly referred to as the 100 yr flood elevation; the nomenclature was never meant to imply it only happens once every hundred years, but since this became a common understanding of it to the layperson, scientists and authors have used the term less, so it is more accurately understood as the storm event having a 1% chance of occurring in a given year.

AE, Floodway - this is the area of the channel that the watercourse needs to ensure the AE zone does not exceed the area anticipated. Usually this is the area of natural vertical depth that a watercourse occupies. This area is critical to remain clear of obstructions so the AE zone does not increase in upstream locations.

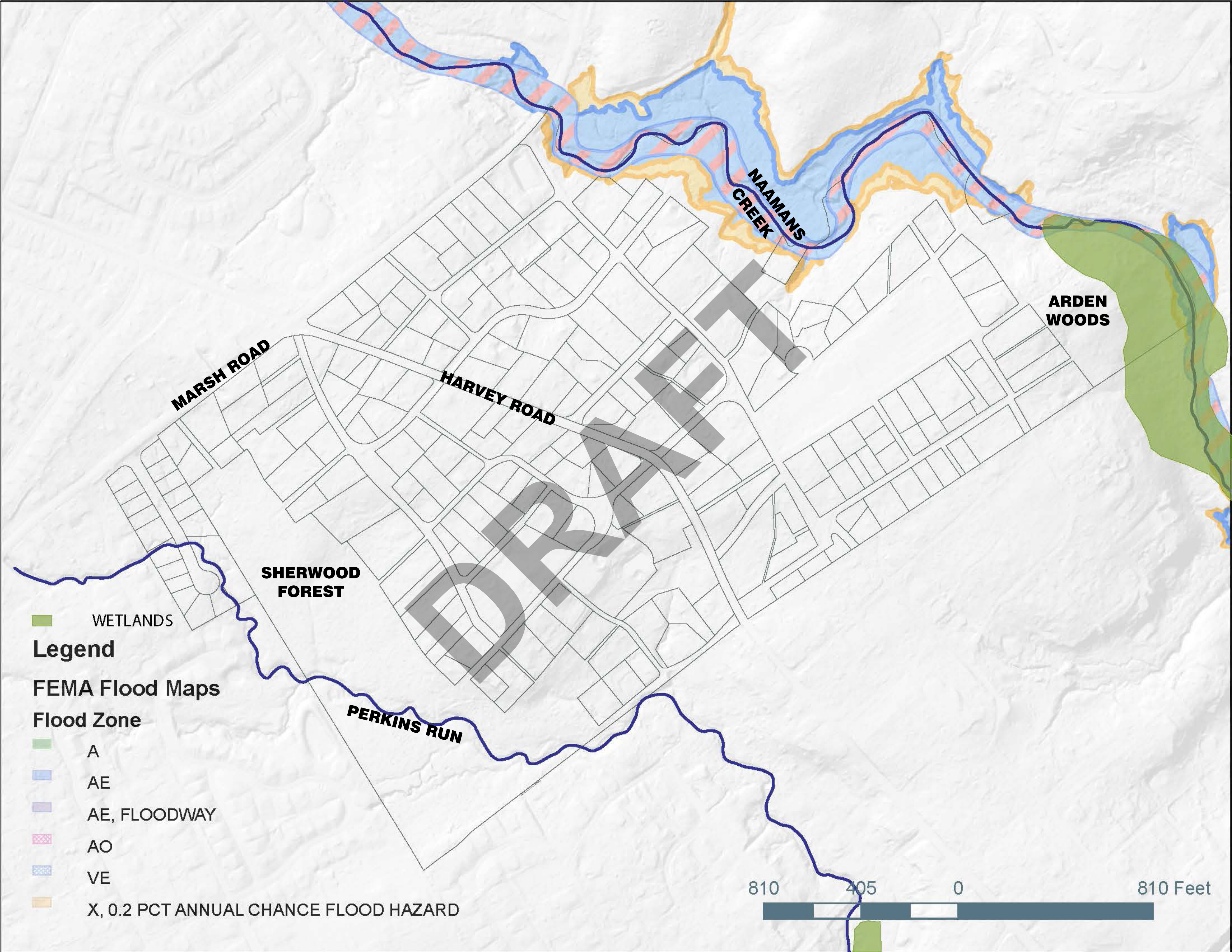
AO - this type of flood zone is not present within Arden

VE - this type of flood zone is not present within Arden

X,0.2 - this is the 0.2% annual flood line, formally commonly referred to as the 500 yr flood elevation; like the AE zone it was poorly interpreted as only happening once every 500 years, when it really means it as a one-fifth chance of happening in any given year.

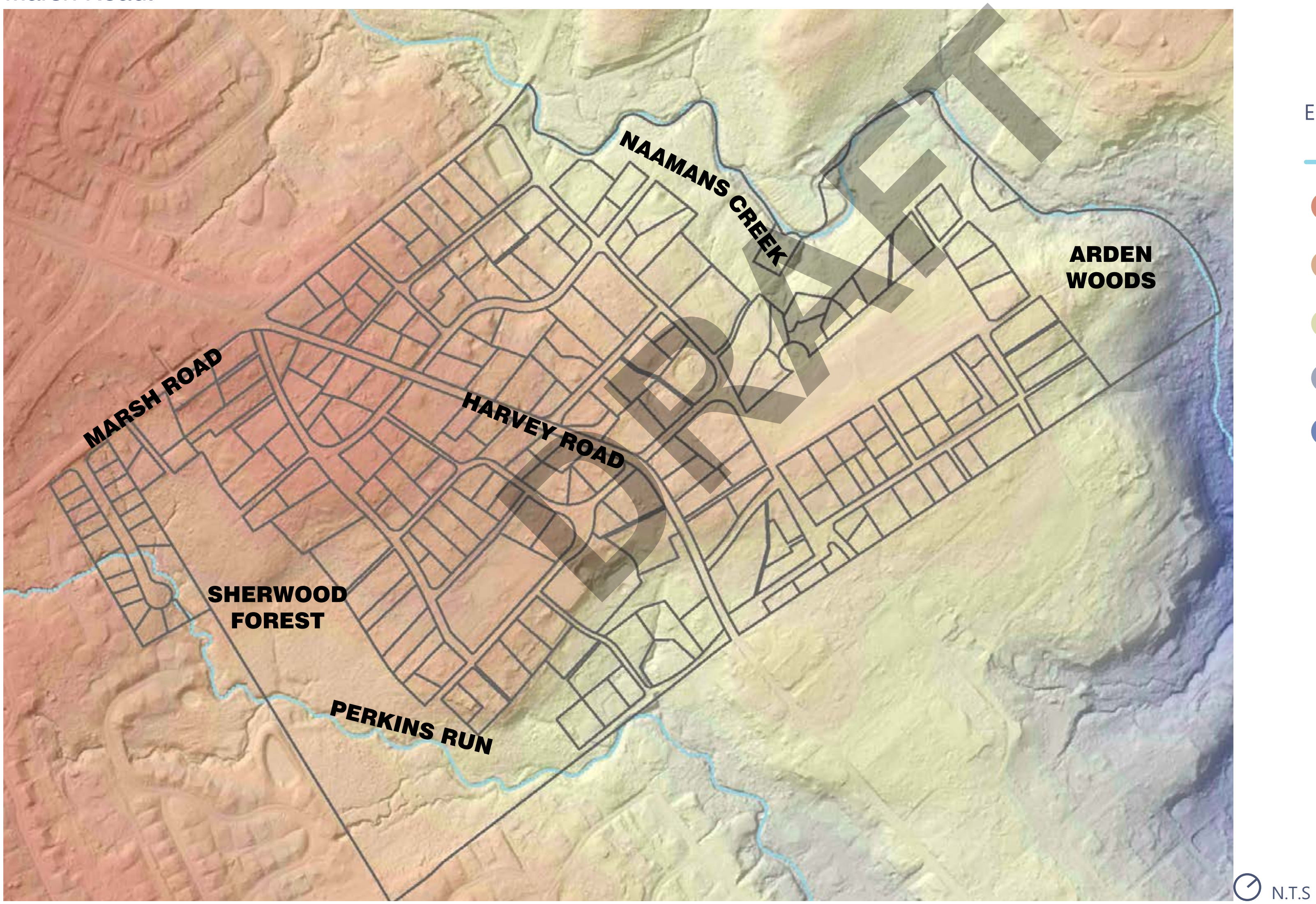
Wetlands - the areas in green appear as wetlands on the DE GIS database but not on the National Wetlands Inventory Mapper, this plan does not propose any work in this area however, other areas of wetlands may exist and prior to any final design, if this area should receive confirmation of wetland status in the future, ground surveys would likely be necessary to confirm the limits and properties of the wetlands, given the public data discrepancies. The DE GIS database codes the area as PFO1Ad, which stands for:

Palustrine (P) : The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt.Class Forested (FO) : Characterized by woody vegetation that is 6 m tall or taller.
Subclass Broad-Leaved Deciduous (1) : Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season;
Water Regime Temporary Flooded (A) : Surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season.
Special modifier (d) : indicates Partly Drained/Ditched


NAAMANS CREEK
ARDEN WOODS
MARSH ROAD
HARVEY ROAD
SHERWOOD FOREST
PERKINS RUN
DRAFT
WETLANDS
Legend
FEMA Flood Maps
Flood Zone
A
AE
AE, FLOODWAY
AO
VE
X, 0.2 PCT ANNUAL CHANCE FLOOD HAZARD
810
405
0
810 Feet

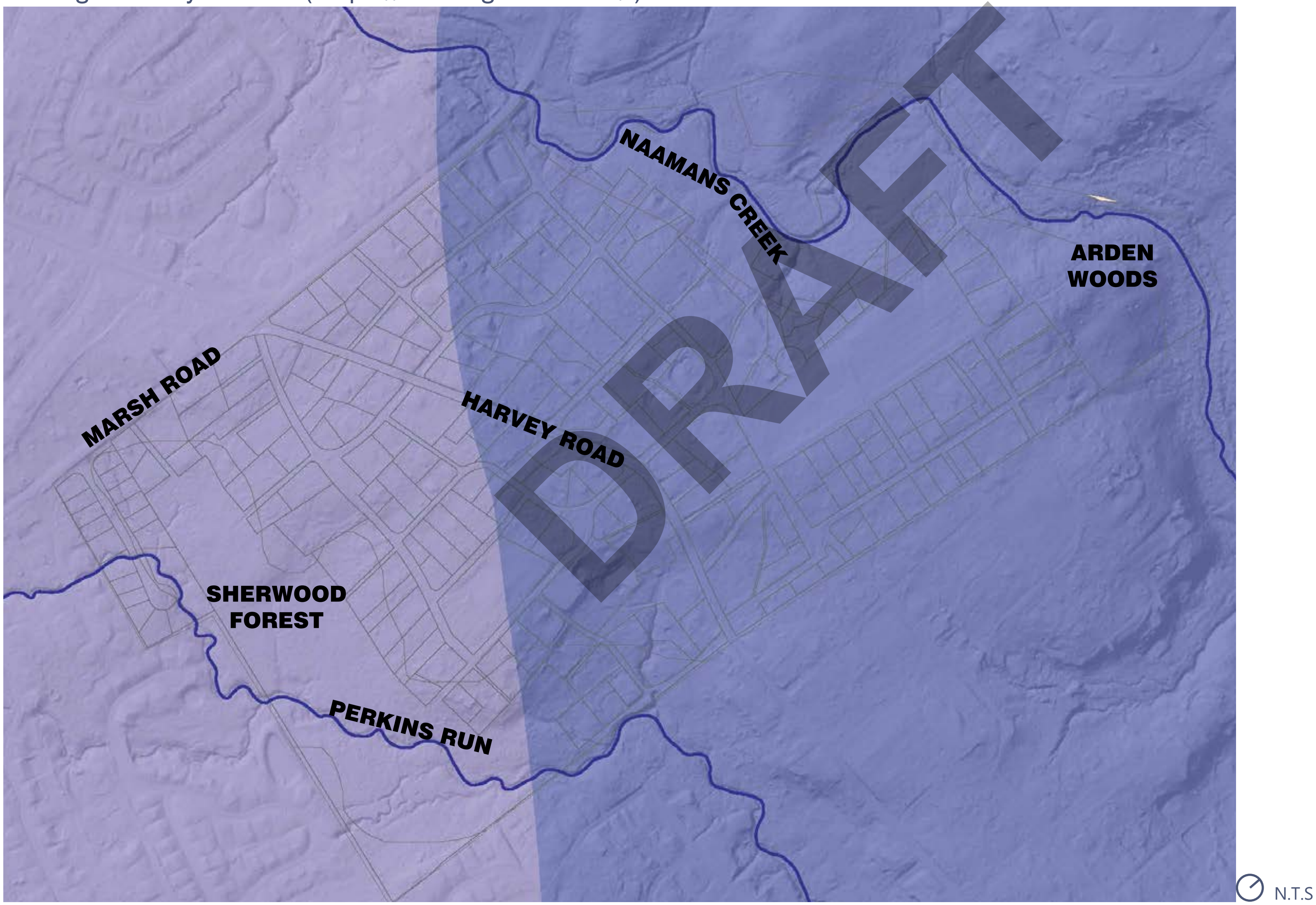
Elevation Hillshade

Elevation contours illustrate the land elevation above sea level. The nuances of this can vary by tidal flux and other technical variants, but for general purposes the elevation at sea level is assumed to be 0ft. A contour map typically shows individual lines with numbers on them. When the image is zoomed out, often the individual numbers are too small to understand. An elevation hillshade is a quick process in ArcGIS that quickly illustrates the topography in areas of high or low contour elevations. As would be expected the lowest elevations in and around Arden are in the creeks. The highest topography with in Arden is at the intersection of Harvey Road and Marsh Road.



Geology

The bedrock in the Piedmont region is typically stable and favorable to the introduction of stormwater BMPs into the landscape fabric. Planning efforts should always check the geology to be aware of any limestone or other soft stones such as dolomite or gypsum. Areas with softer stones in the bedrock composition can be prone to sinkholes or other unforeseen detriments if stormwater is improperly managed in those locations, such as connecting stormwater runoff to underlying aquifers. Arden has two main stone types, Ardentown Granitic Suite and Brandywine Blue Gneiss. The characterizations of each have been noted from The Delaware Geologic Survey website (https://www.dgs.udel.edu/).



Hydrologic Soil Group

stream

Ardentown Granitic Suite

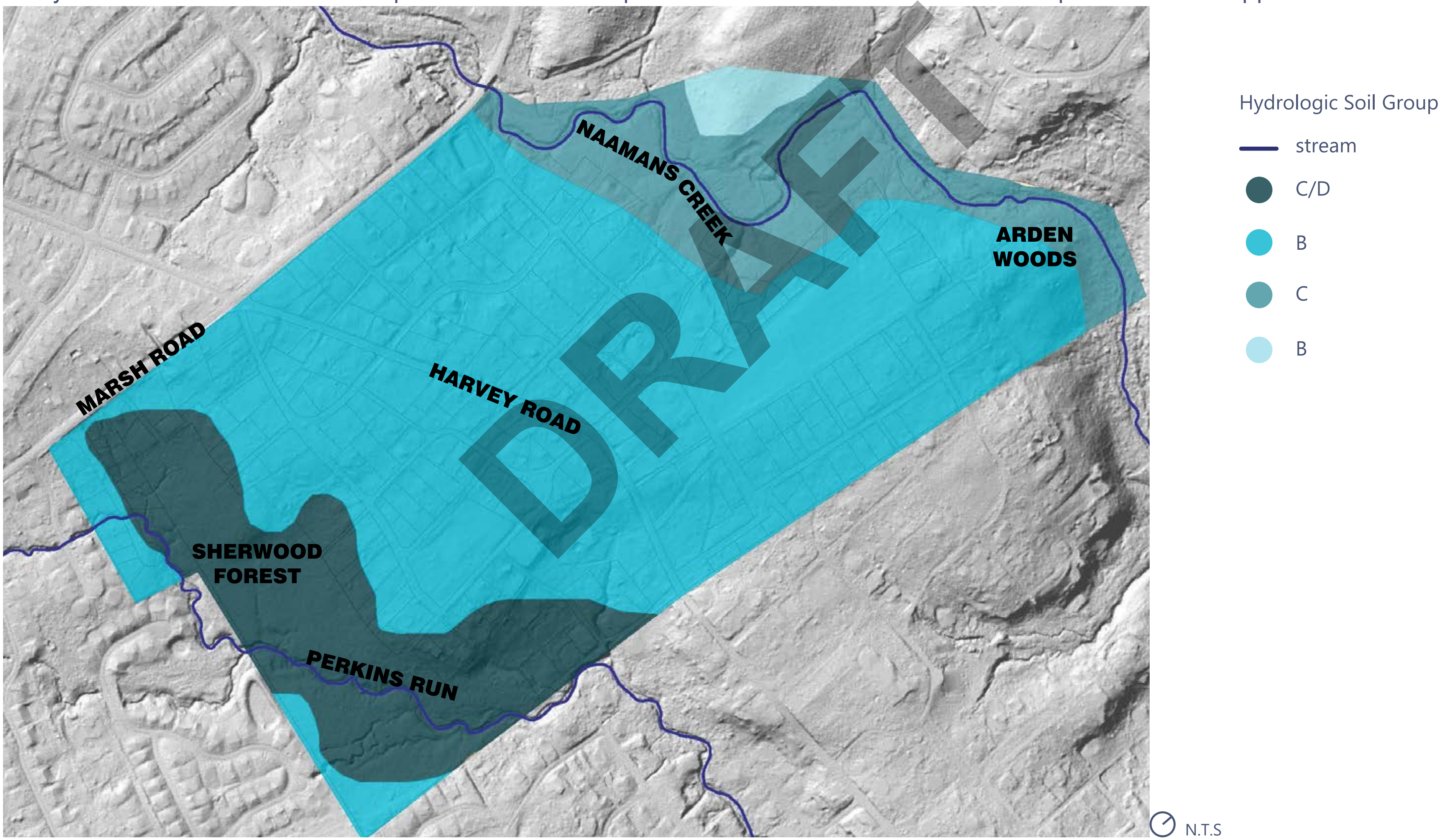
Medium- to coarse-grained granitic rocks containing primary orthopyroxene and clinopyroxene.

Brandywine Blue Gneiss

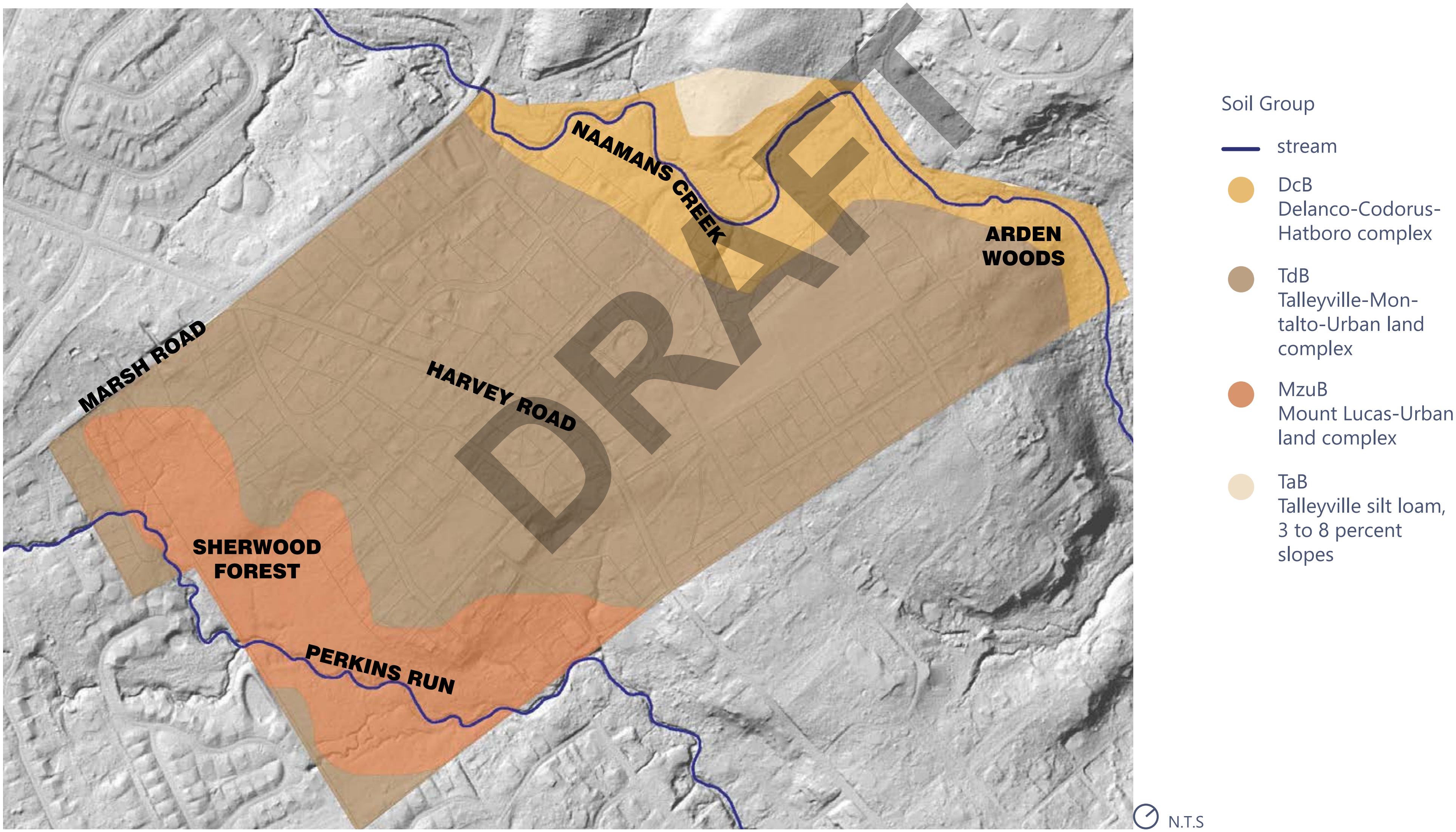
Medium to coarse grained granulites and gneisses composed of plagioclase, quartz, orthopyroxene, clinopyroxene, brown-green hornblende, magnetite, and ilmenite.

Soils

The foundation of water management in built environments, from agriculture to stormwater, involves an understanding of the soil. The USGS provides a nationwide repository of basic soil data for use in planning efforts and desktop analysis. Common practice, including the current DE stormwater regulations, uses this data in early planning; during the construction phases of stormwater management, more site specific testing is completed. The two analysis documents illustrated in this narrative are the soil names and the soil's hydrologic soil group. There are three types of soils within Arden, with the majority of the built areas within the TdB, Talleyville-Montalto-Urban land complex. The full soils report downloaded from the USGS site is provided in the appendices. Each

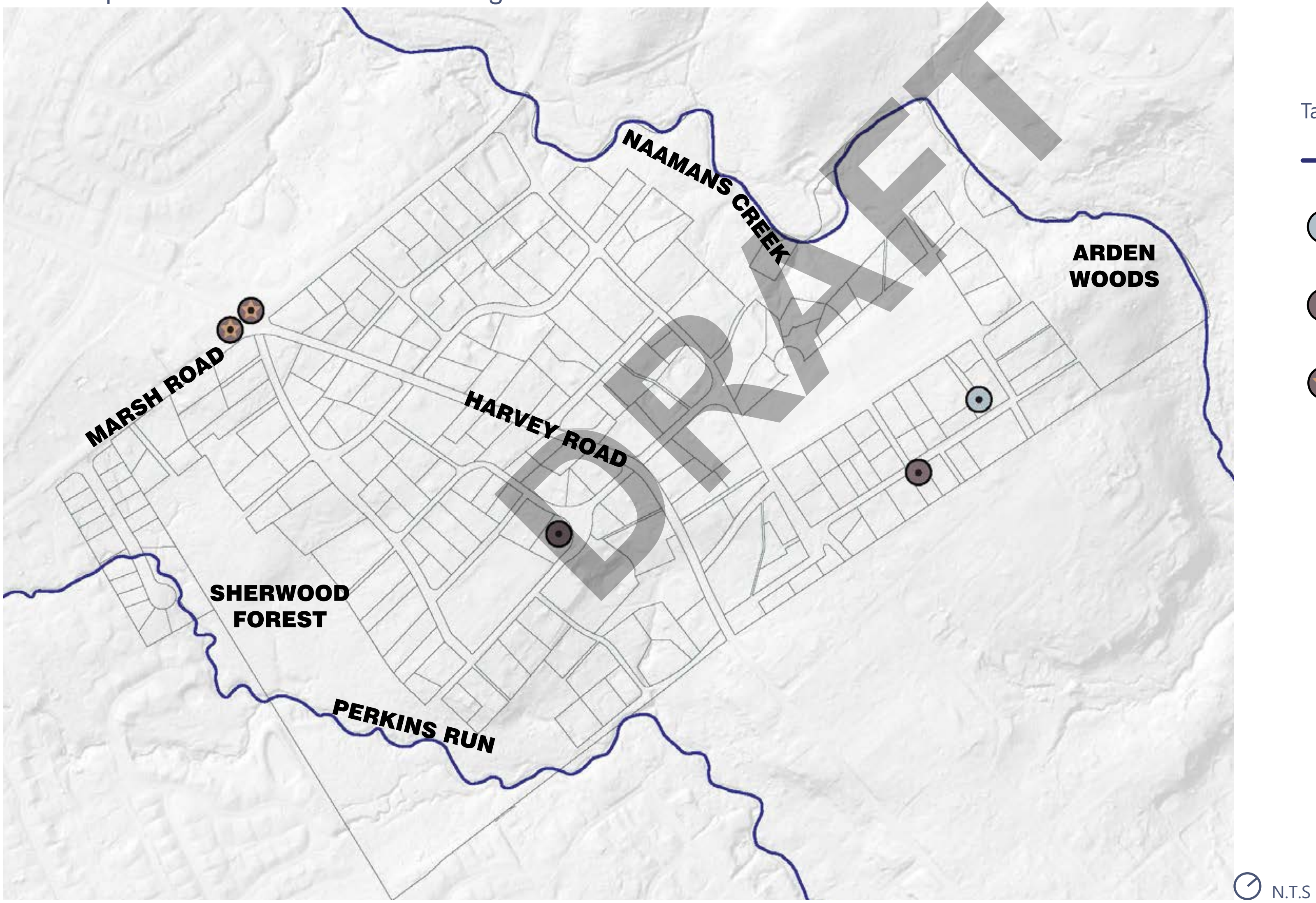


soil type has a different hydroloic soil group, A to D. These groups or ratings are incorporated into preliminary stormwater BMP planning to evaluate how likely rainfall and stormwater are to run-off or infiltrate into the ground, with A being most likely to infiltrate and lease likely to run off and D being least likely to infiltrate and most likely to run off. The majority of Arden soils are ranked B, which is favorable for early preliminary stormwater management BMP planning.



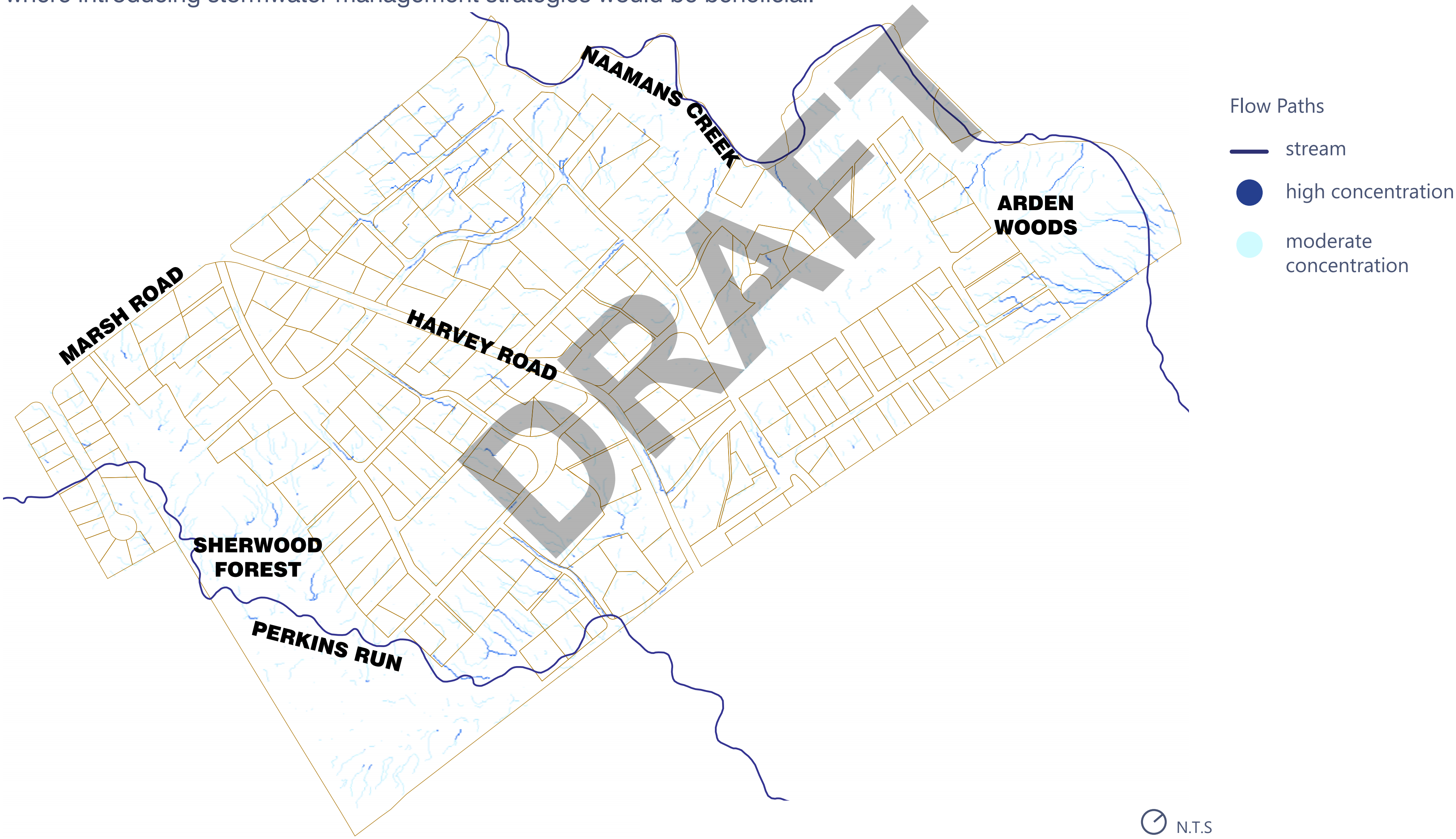
Tanks

Delaware has one of the best repositories for publicly available GIS data. In addition to easy access, different departments have set up various sites to assist planners in providing site specific information. The Delaware Department of Natural Resources and Environmental Control has set up an Stormwater Assessment Study portal (SAS) to assist applicants with permitting submissions to their Department. Any underground utilities or other unknowns can create stormwater conflicts and should be planned for accordingly. The below information can be access at https://dnrec.maps.arcgis.com/apps/webappviewer/index.html?id=04fd9c3ded92443fa82b50c3aa459cd0 . This report conducted no further investigations of the information found on this website.



Surface Water Flow Concentration

This map was a desktop analysis produced by ForeSite to aid in site visits and understanding the general flow of water through the landscape to the adjacent creeks. To determine the areas of higher flow concentration the threshold for the data was set to the flow at the catch basins along Marsh Road. A comparison of this limit with Google Maps appeared to give a likely comparison to what was actually occurring in the landscape. This identified areas to begin site visits and further understand why some areas illustrated stronger flows than others. In some instances it was because drainage infrastructure was in the area, in others it illustrated areas where introducing stormwater management strategies would be beneficial.



2.4 ANALYSIS SUMMARY

The desktop analysis shows that Arden has conditions typical of the suburban character of the region. While wetlands likely were more widespread, through agriculture and later suburban development, they are now limited to isolated areas within woodlands and along stream corridors. The soils are generally conducive to implementing stormwater best management practices while bedrock may limit the type, scale, or depth of BMP proposed within a given area. Drainage patterns show a range of concentrated flow paths, across yards, along streets, through open space and ultimately concentrating in the lower elevations near the receiving streams. It is these varied flow paths and patterns that complicates the introduction of stormwater management after suburban development takes place. Watershed scale degradation can occur quickly, for example raw sewage dumped into streams, but more often occurs over a long period of time as the natural landscape attempts to respond to the built landscape. Changing the direction of flow and reversing the damaging impacts on our streams is a difficult challenge. This challenge can be met successfully and although often interpreted as cliche, every drop does really count, and any opportunity to reduce runoff should be implemented when possible.

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3 LOCAL WATERSHED ANALYSIS

3.1 WATERSHEDS

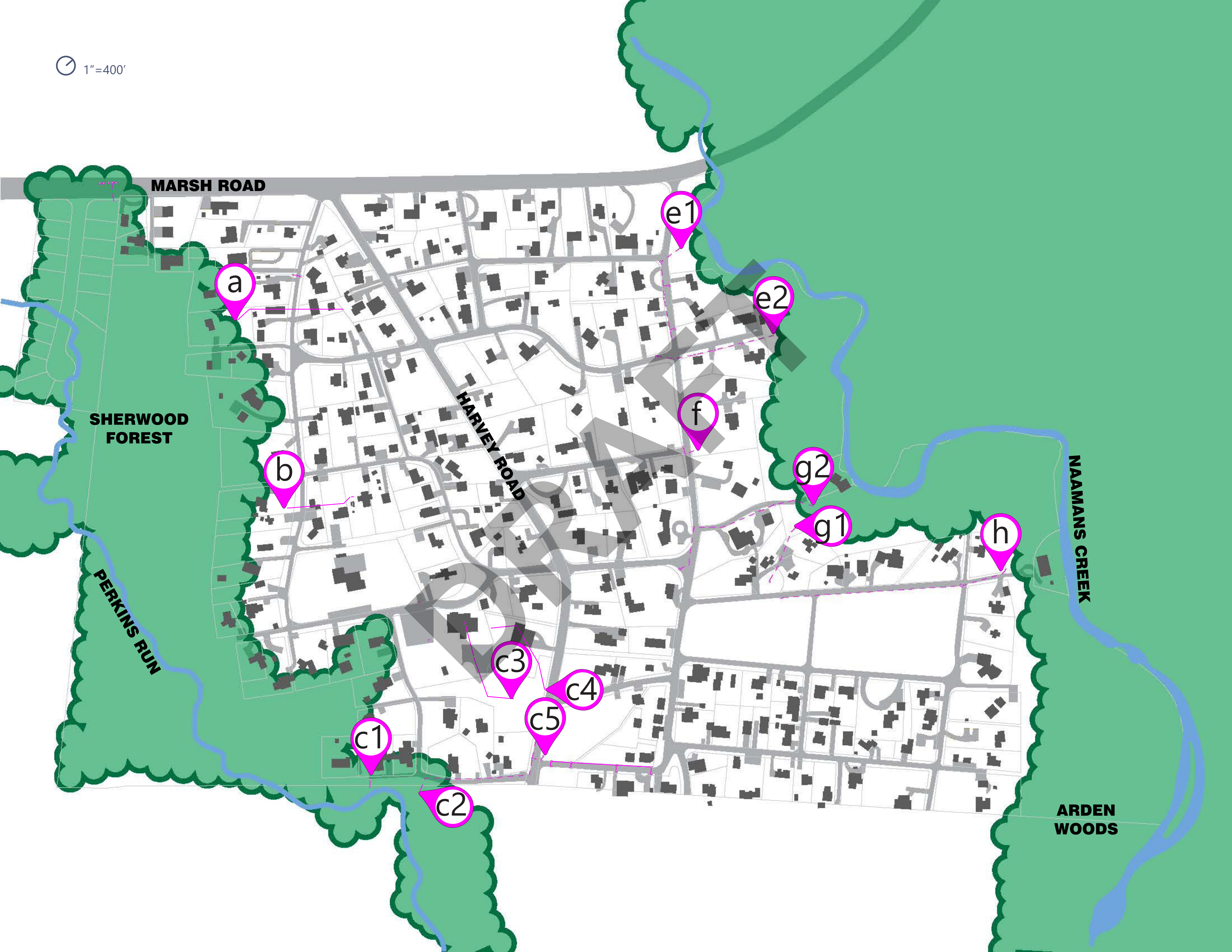
The first step in any stormwater master plan is an understanding of the local watersheds. Using Delaware LiDAR data provided by the State, the image was processed for elevation data and the contours extracted at 1ft intervals. The highest elevations are along Marsh Road and are within the 350 contour range (approximately 350 feet above seal level) and the lowest elevations are within the 50 contour range and are closest to Naamans Creek. Marsh Road is crowned and it appears any runoff from the northern side of the road is collected in a catch basin system that outfalls into Perkins Run for most of Arden's watershed. Harvey Road is also crowned and produces the general east - west divide between Arden lands draining to Perkins Run or Naamans Creek. Using contour patterns of ridge lines and swales, ten (10) watershed boundaries were delineated. Similar to the State delineation of Perkins Run considered part of the Naamans Creek Watershed, some of the delineations, particularly along the eastern boundary, were combined to simplify the mapping and better define potential points of intervention. Upon evaluation of the contours and overland flow patterns, the drainage networks and roadways were reviewed, and watershed boundaries adjusted to respond to any man-made flow patterns. Having a direct hydrologic connection to Arden and no additional east/west connection beyond Arden, the southern half of Marsh Road is considered part of Watersheds A and D. This study is limited to the Village of Arden and runoff upstream of the Arden, such as flows north of Marsh Road leading to the Marsh Road drainage system and then to a tributary of Perkins Run, are not discussed in terms of characterizing the runoff, effective impervious, or BMPs that might be implemented in non-Arden areas. The northern portion of Marsh Road and an unknown limit of impervious coverage to the west, does connect to Perkins Run but was not considered part of Watershed A. During the development of recommendations it was realized Watershed J is connected to Watershed C through gutters. Since one of these gutters showed potential to be disconnected it was determined J should remain its own watershed in the overall map.

The Village of Arden is primarily its own watershed with only the southern watersheds contributing to downstream areas outside of Arden and only the catch basin network on Marsh Road contributing to the northern boarded connected to Perkins Run, there are no east/west connections beyond the Arden limits. Watersheds I and J have an unknown southern boundary. Watershed C appears to be limited in its extension beyond Arden, with a highpoint in Harvey Road just south of the Arden boundary, suggesting little if any stormwater runoff from Watershed C goes beyond Meadow Lane, and any that does quickly makes its way to Perkins Run. With watershed C minimally contributing downstream and the majority of watershed I appearing connected to watershed C through drainage infrastructure, that leaves only Watershed I likely contributing any stormwater runoff to lands outside of Arden.


1"=400'
MARSH ROAD
WATERSHED A
WATERSHED B
WATERSHED C
WATERSHED D
WATERSHED E
WATERSHED F
WATERSHED G
WATERSHED H
WATERSHED I
WATERSHED J
SHERWOOD FOREST
PERKINS RUN
HARVEY ROAD
NAAMANS CREEK
ARDEN WOODS

3.2 DRAINAGE NETWORKS

A drainage network is a series of built structures, such as catch basins, pipes, and outfalls that manipulate the natural overland path stormwater will take through a landscape to the receiving waterway. As noted in the introduction, the infrastructure at Arden illustrates typical design strategies for when it was built, as well as a patchwork of drainage 'Band-Aids' for problem areas that occurred during later development. Collection structures are often situated in the low points within the landscape and direct water underground through a pipe to an outfall location closer to the receiving waterway. The catch basins within Arden appeared relatively stable with some illustrating minor settling and wear of the concrete collar and could be adjusted for better function. The catch basins along Harvey Road, are within the Arden limits, but fall under the jurisdiction of the DelDOT. ForeSite met with the Civic Committee to review these catch basins shortly after the remnants of hurricane Isaias passed through New Castle County. These catch basins were heavily clogged with sediment and showed signs of subsidence and erosion. As discussed previously, this plan is not intended to be a drainage plan but water quality is regularly effected by poor and/or excessive drainage. A full evaluation of drainage infrastructure was outside the scope of this plan, the networks identified in the following pages provide a narrative based on site visits and conditions visible on the surface. This inventory is also provided for the residents to gain a better understanding of the infrastructure present and how it was likely designed to work, so that the networks can be properly maintained and the residents able to respond to small problems before they develop into significant and costly landscape impairments.


1"=400'
MARSH ROAD
HARVEY ROAD
SHERWOOD FOREST
PERKINS RUN
NAAMANS CREEK
ARDEN WOODS
DRAFT
a
b
c1
c2
c3
c4
c5
e1
e2
f
g1
g2
h

a

There are two catch basins at the north end of Sherwood Road. These two connect under the road and are piped out to the west towards the fire road within Sherwood Forest. This image is of the outfall to those catch basins. Debris collection was observed on the catch basins but overall, the system appeared stable.

b

There are two catch basins at the intersection of Sherwood Road and Lovers Lane. These two connect under the road and are piped out to the west towards Sherwood Forest. This image is of the outfall to those catch basins. Debris collection was observed on the catch basins but overall, the system appeared stable.

c1

This is a PVC flared end section pipe that collects water on Meadow Lane and pipes it to the creek just beyond the road. The invert showed signs of sediment deposition. This gravel and sediment will likely travel very quickly to the creek during rain events and should be cleaned regularly to avoid introducing gravel with potential roadway chemical impairments, such as oil, into the creek.

c2

This is a catch basin within a concrete gutter along Meadow Lane (under shrub branches). Debris deposition could be seen in the gutter as well as leaves over the catch basin, as visible in the image. This catch basin is connected to same pipe network as the the additional images shown for c2.

c2

There are two catch basins along the west side of Harvey Road. Both were visibly clogged with debris. These two catch basins are considered part of Harvey Road and under DelDOTs road maintenance. However the catch basins appear to connect underground to the catch basin on Meadow Lane and ultimately discharging to the concrete flared end section to the creek. A FOIA request of the DelDOT owned catch basins in the area is included in the appendices.

c2

This image shows the failing concrete outfall of the drainage network for c2. ForeSite was called to a site visit when the paving along Meadow Lane subsided after a large rain event. ForeSite provided recommendations for repairs to the outfall area. This network appeared in poor condition with multiple areas of the drainage system failing. The two catch basins on Harvey Road appear critical to the function of this system. Since they are not under the jurisdiction of Arden it is suggested that Arden monitor these two catch basins and request they be cleaned as debris collection impairs the function of the network to collect stormwater runoff.

c3

There is one catch basin in the parking lot to Guild Hall. The catch basin appears to be piped underground and outfalls lower down on the slope behind the parking area. The water then appears to travel through small swales, such as that pictured, to the open area in the Memorial Garden. The network appeared stable. The corner of the parking lot opposite the catch basin did not appear stable and stormwater was eroding the corner of the lot.

c4

There is a network of small catch basins that collect water in front of Guild Hall and the residence adjacent to Guild Hall. The outfall location was not able to be located but it is assumed likely in the hillside that drains to the open area in the Memorial Garden. The network appeared stable on the surface but ponding was visible in several locations throughout the area. It is likely some of this ponding can be mitigated through BMP implementation but to what extent the drainage network is or is not functioning properly was not able to be ascertained.

c5

There is a network of multiple catch basins along Lower Lane. The outfall location of this network was not clear. It is assumed it connects to this open area that connects underground to the system on Meadow Lane. This pipe is believed to be providing a collection point for the east side of the Memorial Garden to be directed under Harvey Road to free the intersection of ponding. The network was provided a separate number but if Lower Lane does connect at this point and joins Meadow Lane it would be part of the already taxed c2 network.

e1

There is a network of multiple catch basins along Millers Road north of Hillside Road, that run north and outfall into Arden Woods via the concrete gutter shown in the image. The outfall has created an eroded channel through the woods to the creek. The concrete gutter should be removed and natural techniques such as log sills and plantings used to stabilize the channel.

e2

The network of catch basins at the bottom of Hillside Lane appears to connect to an outfall that is just at the edge of the woods beyond the roads end. The outfall location could not be found but a small channel was visible and assumed to be the likely flow path from the catch basins to Naamans Creek. The channel did not appear significantly eroded.

f

At the bottom of Little Lane is a small drainage network that has caused a significant amount of forest erosion. The network is simple with two catch basins at the end of Little Lane that connect underground and outfall just to the other side of Millers Road in the woods. There is a concrete gutter to catch road run off that sits on top of the outfall pipes. From this point just after the road stormwater is unmanaged down to the creek.

g1

The g1 and g2 networks outfall in roughly the same location such that a bowl shaped depression, per the image, has formed in the landscape. The area is eroded but benefits from the repairs done to the sewer on the downslope side of the collection area. The stabilized drop in the area of the sewer likely slows the water down in this area, and slows the severely eroded channel downstream from eroding further up into the landscape.

g1

This is image illustrates the catch basin network that has a visible pipe outfall in the bowl area pictures previously. The catch basin in the middle right of the image connects to that outfall downstream and upstream connects to the catch basin in the outdoor theater at the base of the stage.

g2

This is the bottom catch basin for the drainage network of catch basins along St. Martins Lane. The structure was clogged with debris and larger sticks but overall appeared in solid condition. The water from this system travels under the driveway to outfall to a swale that leads to the bowl area pictured previously.

h

The network of catch basins along Woodland Lane, including the one that catches overflow from the existing rain garden, discharges to an outfall on the north side of Woodland Lane. The image above shows the channel eroded by the outfall point.

3.2.a drainage infrastructure

As the catch basin network along Harvey Road illustrates, maintenance is a critical component to drainage infrastructure function. Good drainage is not the focus of this plan but improper maintenance can lead to sever water quality impairments over time. With that said, good drainage can also negatively effect water quality when not properly designed for the receiving waterway. Areas like this are examples of slow drainage reducing negative impacts downstream. There are many instances where the undersizing of pipes and culverts have prevented large scale erosion by forcing water to pond and slow down before entering the more natural portions of the Arden's landscape. The primary point of this section is to inform the residents of Arden what they have and what they should look for, with the ultimate goal being a good balance between functioning drainage infrastructure and regenerative stormwater practices. Concrete gutters are used throughout much of Arden for conveyance along roadways. There are several types with the two images below being the most common. The image on the left illustrates a rolled curb and gutter, note the curving concave shape. The image on the right illustrates an upright curb and gutter system. When this system crosses a driveway it transitions from upright curb to a mountable depressed curb. Both systems work well at conveyance and the primary maintenance is to keep them clear of debris, which is easily accomplished with regular street sweeping, which is a type of BMP. Although the depressed curb may appear "higher" than the rolled curb, often the vertical distance between the low point in the gutter and the driveway is the same as a depressed curb, the soft transitions create an optical illusion. It should be noted this is often the case, but the rise in the images was not measured to confirm; there are several locations where the depressed section of curb visibly offers inadequate capacity and the taller roll curb section without the reduced height should be used. The primary problem with this system is not the system itself, but where they stop. There are several instances noted in this plan where both drainage and water quality have been effected because concrete gutters along roadways end abruptly with no directed path for the stormwater, thus it seeks the lowest gradient that can lead anywhere, including a residence. Valley gutters can also be found in the Arden drainage infrastructure. These are similar to

roadway gutters but are often used to cross a road as opposed to running parallel, like the one at the bottom of Meadow Lane. The maintenance of these would be the same, to keep them clear of debris and monitor the stability of the area where they end.

Not all catch basins work the same. The image to the right shows a traditional flat catch basin. This style is usually less costly at implementation but overtime looses function and often creates more costly fixes downstream. As illustrated in the image, they easily clog with debris and once clogged the water seeks a new flow path. The image on the bottom left is the most ideal style and as catch basins are replaced in Arden, it is recommended all basins be transitioned to this style. The grate works as a traditional flat basin but should the grate be clogged or become clogged during a heavy event, such as a large rainfall during the fall season when there are lots of leaves on the ground, the water will still be able to enter the drainage network via the open vertical area to the back of the catch basin. If there are concerns about small humans and animals getting caught, they do make vertical grates for these areas, even with a grate, the vertical rise area will continue to let water enter the network and drain properly.

The image to the bottom right illustrates a likely mis-installation of the same catch basin to the bottom left. Note the grate is set too far back and while there appears to be a rear opening, none actually exists such that it is easily clogged with debris.

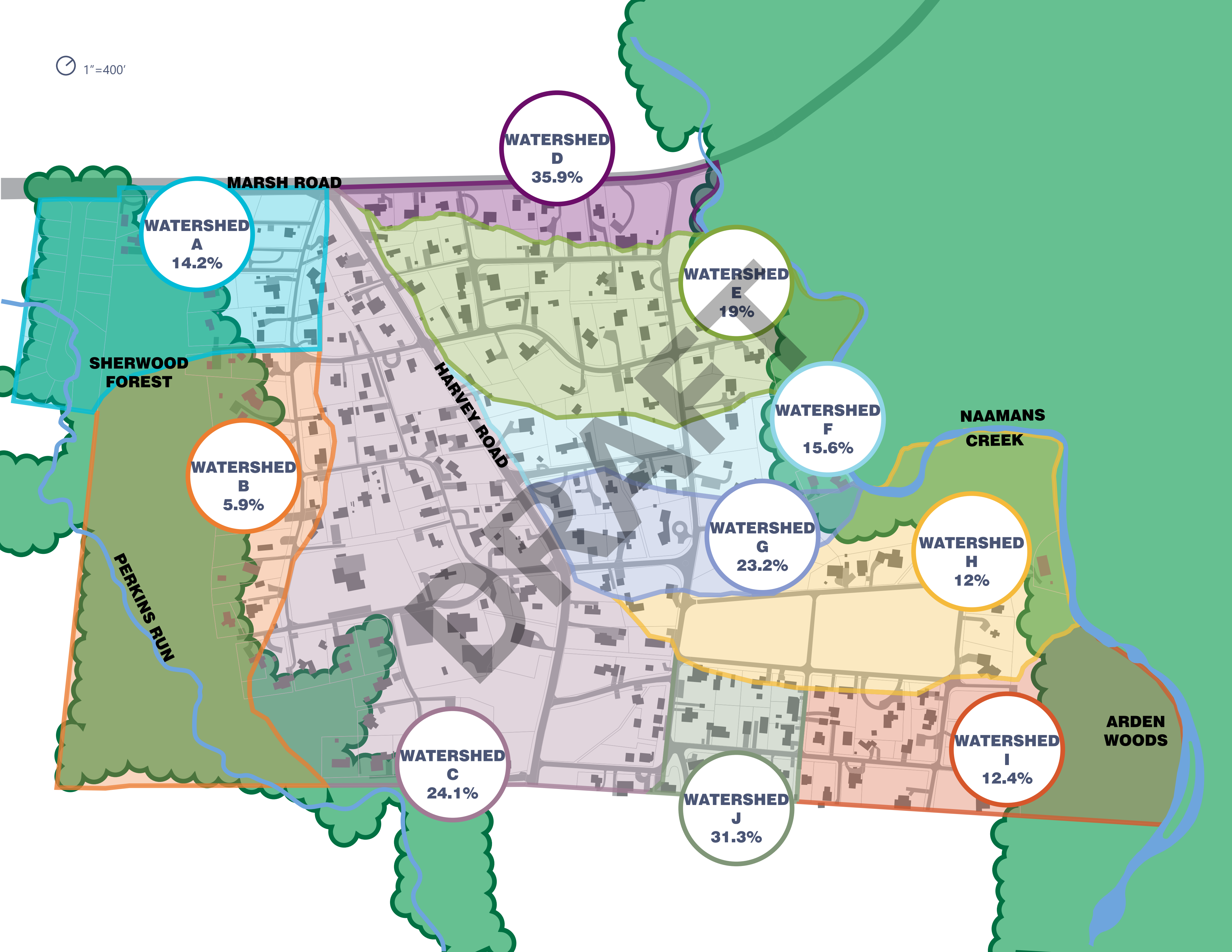
3.3 IMPERVIOUS COMPARISONS

The final step in the inventory and analysis, prior to recommendations and site specific design opportunities, was to evaluate each watershed using the Impervious Cover rational developed by the Connecticut Department of Environmental Protection. As noted earlier, the impervious cover for Arden as a whole is ~16.5%. Based on the CTDEP methodology, impervious cover over 11% is believed to negatively effect water quality. Using the watershed map developed based on contour data and drainage networks the final question was which watersheds within Arden are the most impervious and likely contributing the most to water quality impairments. The impervious coverage was created using public data as feasible and augmented with edits based on aerial imagery. The mature tree cover did produce abnormal line work in both the public data and created data. Residents are highly likely to see areas of discrepancies, but the discrepancies are very unlikely to change the overall evaluation of the site since this study looks at watersheds on a broad master plan scale. For example, nuances of a houses roof lines may be simplified, or a driveway may connect to a residence in the wrong location, but the mass of the house and the mass of the driveway are still accurate enough for comparative purposes and treatment evaluation. The adjacent map illustrates the following:

In order by Watershed	In order by Percent Impervious Cover
Watershed A - 14.2%	Watershed D - 35.9%
Watershed B - 5.9%	Watershed J - 31.3%
Watershed C - 24.1%	Watershed C - 24.1%
Watershed D - 35.9%	Watershed G - 23.2%
Watershed E - 19%	Watershed E - 19%
Watershed F - 15.6%	Watershed F - 15.6%
Watershed G - 23.2%	Watershed A - 14.2%
Watershed H - 12%	Watershed I - 12.4%
Watershed I - 12.4%	Watershed H - 12%
Watershed J - 31.3%	Watershed B - 5.9%

The individual evaluation of each watershed greatly changes the overall evaluation of Arden. Of the ten watersheds, only one, Watershed B, falls below the Impervious Cover rational of 11%, and it is worth noting that this area has a stable outfall with little erosion downstream of it. Watersheds I and H are only slightly above the 11% threshold. Considering the CTDEP methodology was conservative in using 11% over 12%, these two watersheds, 12.4% and 12% respectively, are likely minimally contributing to water quality impairments within the overall Arden watershed. Studies suggest most developed land uses exceed the threshold of 10—15 percent impervious cover, which defines a healthy watershed or stream system, and watersheds with over 25% impervious cover frequently contribute significant pollutants and erosion, to the point that they can not support aquatic life. (http://nemo.udel.edu/manual/chap2web.pdf)

Per prior discussion, Watersheds A and D include the southern portion of Marsh Road in the evaluation and the majority of Watershed J is connected to Watershed C through drainage infrastructure.



1"=400'
MARSH ROAD
WATERSHED A 14.2%
WATERSHED D 35.9%
WATERSHED E 19%
SHERWOOD FOREST
HARVEY ROAD
WATERSHED F 15.6%
NAAMANS CREEK
WATERSHED B 5.9%
WATERSHED G 23.2%
WATERSHED H 12%
PERKINS RUN
DRAFT
ARDEN WOODS
WATERSHED I 12.4%
WATERSHED C 24.1%
WATERSHED J 31.3%

4 MASTER PLAN

4.1 LEASEHOLD SCALE OPPORTUNITIES

Residents of the Village of Arden don't need to look far for inspiration and ideas on how they can support water quality initiatives on their own leasehold, several properties within Arden have already taken steps to aid in stormwater conservation. The awareness of environmental opportunities through stormwater conservation has grown significantly in the last 20 years. As a result many informative and helpful references exist authored by universities, government agencies, and non-for-profit organizations. This section of the plan has been prepared as a reference section with links to local resources and a short narrative on the applications as they relate to the Village of Arden. The section has been divided into two broad categories, softscapes and hardscapes, with additional subcategories as needed. Softscapes are opportunities that primarily utilize natural elements around the leasehold to improve water quality; hardscapes are opportunities that primarily manipulate the built environment to improve stormwater quality. For all text and reference material suggestions in this section, it should be understood these are provided for informational purposes only; these reference materials have been included based on the authors assessment, they are not the ownership of the authors; for all opportunities mentioned, it is suggested a professional be retained if there are any questions or concerns regarding implementation within the context of a specific location. When it comes to stormwater, every drop actually does count. Small initiatives aggregated across a community can lead to significant reductions in stormwater runoff, erosion, and pollutant discharges.

this leaseholder is utilizing a rain barrel to capture stormwater from their roof; captured water can be recycled for many reasons such as watering garden plants during periods of low rainfall; regardless of how you re-use the water, rain barrels aid in slowing down run off to downstream watersheds.

4.1.a softscapes

The vegetation around our homes provide a multitude of opportunities to reduce runoff and its associated stormwater quality impairments. This section includes resources for three common landscape typologies found around our homes: lawns, plantings, and healthy soils. For each reference, a link is provided in this text and when feasible the document was downloaded and included within the appendix section.

1. Lawns

Forests are highly productive landscapes and the intertwined structure of vertical and horizontal matrices of leaves, branches and roots, allow them to naturally balance infiltration and rainfall runoff within the forested footprint. Sherwood Forest and Arden Woods are a tremendous asset to the Village of Arden for a multitude of reasons, including providing a large riparian buffer to mitigate the water quality impairments produced in the built landscapes of Arden higher up in the watershed. The residential landscapes within Arden continue a forested canopy with many mature trees accenting lawn and garden beds. Although not the traditional layered structure of forest composition, these areas of lawn and garden beds can be maintained and augmented to increase water quality treatment. In addition to the aesthetic and ecological benefits of Arden's beloved trees, they are an effective stormwater management systems.

The resources below provide several recommendations for creating a healthy lawn to improve the infiltration of stormwater and overall ecological health. A healthy lawn does not have to look manicured like a golf course; healthy plants, even if a diverse mixture, should be the goal. Lawns in good condition absorb rainfall and slow runoff. One of the best things you can do for a lawn and to improve infiltration is to aerate turf areas. As mentioned in the following discussion on soil health, aerations can bring big benefits to turf areas. One often over looked opportunity is the option to increase garden plantings within the drip line of mature trees to reduce bare ground subject to erosion. Mature canopy trees isolated in a carpet of turf can be very stately and attractive. Unfortunately, this is not the forested matrix mature trees thrive in, in this eco-region. The attractive tree trunks can still be complimented by a low growing garden bed near the base of the tree instead of turf. In general, turf grasses and trees prefer two different ecosystems, turf grasses love open meadow-like conditions, like our native grasses, trees benefit from being in forests. Although cultivars do exist, turf grass species don't do well in low light conditions and bare earth often develops within the drip line, the bare soils don't benefit the tree and can lead to soil erosion. Areas where insufficient sunlight exists for turf are an ideal candidate to increase garden plantings. Do not add soil on top of mature tree roots as this can kill the tree. Working garden plants into the gaps between roots can be beneficial to the trees and prevent water quality impairments due to soil erosion.

> Section 5 of this reference provides 10 recommendations for healthy lawn care on pages 22-25
> "The Homeowner's Guide to Stormwater";
> https://agsci.psu.edu/aec/research-extension/conservation-tools/stormwater-management

The Delaware Nursery & Landscape Association has created several helpful guides in their Livable Delaware series. For lawns, their Livable Lawns brochure gives helpful tips in both establishing and maintaining a healthy lawn area. For garden beds, page 7 of their Livable Landscapes brochure provides guidance on establishing plantings under mature trees. https://www.dnlaonline.org/resources/livable-delaware/

2. Soils

The soil food web is a dynamic system of microscopic activity below our feet. With only a few decomposers such as worms and beetles visible to the naked eye, it is often easy to forget we can take an active roll in promoting a healthy soil structure. A healthy soil food web creates pockets or pore space within the soil matrix, these pockets are available for air to assist in decomposition and during rain events for water to be temporarily stored and re-used for plant uptake and other soil processes. Any water captured and infiltrated within the soil matrix is water that is not increasing stormwater run off and likely negatively impacting water quality downstream. Soil compaction greatly reduces pore space availability, reducing the overall ability for a functioning soil matrix. It doesn't take a monster truck to compact the soil, our own footsteps can have a negative effect overtime, particularly in our recreational lawn areas. The Village of Arden has two large areas of recreational lawn space, the area surrounding the Buzz Ware and the green adjacent to Cherry Lane. These, and any other lawn areas subject to regular foot or animal traffic, will benefit from the addition of aeration to the regular maintenance regime. It is recommended lawns be aerated in the spring and fall. Additionally, all community turf spaces should be aerated in the week following community events such as the Arden Fair. It may take several seasons of aeration for the results to show, however turf areas will look and perform better with regular aeration. Soil aeration is easily undertaken with a plug aerator. An aerator removes plugs of soil allowing air and water into the plug void, this increase of water and air acts to jump start other processes in the soil and improve infiltration. The addition of compost to the aeration process is also beneficial, this can be done with a thin layer of organic materials or the addition of compost tea. When implemented properly the results of improving soil health can be quite remarkable.

Page 13 of the Livable Lawns brochure referenced in section 1 Lawns, provides an introduction to soils; https://www.dnlaonline.org/wp-content/uploads/2015/08/Livable-Lawns.pdf

The Ecological Landscape Alliance provides a short article on Compost Tea; https://www.ecolandscaping.org/04/installing-and-maintaining-landscapes/lawn-care/using-compost-tea-on-turf/

3. Plants

The more opportunities leaseholders take to increase infiltration on their lands and slow the rate that water runs off their leasehold, the less rainfall will concentrate into runoff and negatively impact water quality downstream. Impervious surfaces lack the ability to infiltrate and create high run off volumes during storm events, pervious surfaces are better, but not all previous surfaces act equally. Think about how easy is it for you to push down and run over a blade of grass as opposed to shrub, the shrub provides much more resistance to bending. While much better than an non-vegetated surface, during high rain events it doesn't take much for water to push down short turf grass and increase in velocity downstream, as opposed to infiltrating into the soil matrix. When you reduce lawn and impervious coverage and increase planting areas, you typically slow down the runoff and increase opportunities for infiltration. Native versus exotic plants aren't significantly different when it comes to slowing down stormwater runoff, but they have very different effects to the greater ecology of the landscape. This plan recommends utilizing native plants primarily and augmenting with non-invasive exotics where specific horticultural attributes are desired. The use of non-native invasive plants is strongly discouraged and has documented negative ecological consequences. Miscanthus sinensus is an ornamental grass imported from Asia and is still sold in nurseries for its many attractive cultivars. The grass has become invasive in meadow habitats and reduced the colonization of native plants such as common milkweed plants, Asclepias sp., a host plant for many native moth and butterfly species. A reduction in plant diversity within the landscape can lead to a decrease in soil health. Delaware has many great resources for utilizing native plants and increasing native landscapes.

The Livable Landscapes and Livable Ecosystems brochures from the Livable Delaware series provide guidance on using and siting various native plants.
https://www.dnlaonline.org/wp-content/uploads/2015/08/livable_plants_home_landscape.pdf
https://www.dnlaonline.org/wp-content/uploads/2015/08/Livable-Ecosystems.pdf

The University of Delaware hosts the Flora of Delaware Online Database. This is a botanical listing of Delaware native plants which was created with the help of the State of Delaware Botanist.
https://www.wrc.udel.edu/de-flora/

There are lots of great references on the use of native plants in the landscape, but finding the plants for sale can be difficult. In addition to many helpful guides, and training programs for the home gardener, the Mt. Cuba Center keeps an updated list of local nurseries that offer a good selection of native plants. https://mtcubacenter.org/action/

4.1.b hardscapes

Reducing the effective impervious within the Village of Arden is the primary goal of this plan because it results in a direct improvement in the quality of surface water runoff, it reduces erosion and downstream flooding and increases the longevity of drainage infrastructure. This plan provides recommendations for specific locations throughout Arden in the Village Scale Opportunities section. These opportunities capitalize on common lands and areas in close proximity to common lands, but the reduction of effective impervious is critical to reducing water quality impairments within all Arden landscapes. This section provides references for leaseholder opportunities to reduce effective impervious that are slightly more DIY friendly. Although more feasible for the weekend gardener or handy-person, effective stormwater management requires good design, accurate implementation, and careful monitoring upon completion. For any task undertaken by a leaseholder, a skilled design professional and contractor should be retained when needed, and any installations carefully monitored upon completion to make sure no unintended stormwater flows develop around your home or a neighbor's home. For each reference a link is provided in this text and when feasible the document was downloaded and included within the appendix section.

1. Driveways

Our driveways allow our cars to connect us to the intercontinental network of roads and highways and to travel, sightsee, visit and help others. This critical component of our home landscape also provides areas for play and outdoor activities. It is also a large area of impervious surface that can produce significant volumes of stormwater runoff in a short amount of time. The driveways within Arden vary by material, each one with its own contributions to water quality impairments. Asphalt driveways are stable but shunt water away the fastest and have no opportunities for stormwater infiltration. Gravel driveways are also common throughout Arden and in several locations washout was observed, a clear indicator of rapid stormwater runoff. Although gravel may seem more pervious than asphalt, it rarely is, as installations usually require some type of geo-textile fabric under the stone and even without, the constant vehicular use of the driveway creates heavy compaction and a surface that functions equally to asphalt in its contribution to water quality impairments and downstream flooding. Although no completely dirt driveways were noticed during site visits, some locations not visible from the streets appeared tan in color on aerial imagery and bare dirt from tire ruts at the edges of roadways were seen throughout Arden. Areas of bare earth should be eliminated within the landscape.

Many unintended pollutants can be found on driveway surfaces such as particles from tire ware, oil drips from vehicles, and gas drips from refueling landscape equipment. In stormwater there is a phenomenon known as the first flush, the amount can vary but the concept remains the same, the first flush of rainfall carries with it the highest levels of stormwater pollutants. The longer the time period is between rain events, the greater the amount of pollutants are found within the runoff. Regardless of what the driveway materials are, every leaseholder can increase opportunities for the first flush to be infiltrated into their landscape and prevented from washing downstream. Two effective methods for mitigating driveway runoff are transitioning the paving to porous pavers or porous asphalt to allow for infiltration through the driveway materials themselves, or directing the runoff to a rain garden where the water can be slowed down and allowed to infiltrate; rain garden plants and soil microbes around plant roots can also aid in capturing and breaking down pollutants.

> Replacing a driveway with permeable pavers or porous asphalt is best done by a professional paving installation contractor. If a leaseholder wants to retrofit a smaller area most companies that sell permeable pavers offer a general installation guide such as the company TechoBlock. Their websites also provide you with local retailers to purchase products from.
> https://www.techo-bloc.com/globalassets/technical-ressources/tb2019_installation-guides_ca_perm-pavers.pdf
>
> Rain gardens require proper siting to capture runoff but with careful planning and monitoring after completion, they can be implemented with a little hard work. “The Homeowner’s Guide to Stormwater” mentioned in the lawn section provides some planning guidance, and a brochure put out by the Partnership for the Delaware Estuary provides additional information
> https://agsci.psu.edu/aec/research-extension/conservation-tools/stormwater-management
> https://s3.amazonaws.com/delawareestuary/pdf/rain_gardens.pdf

2. Roof Runoff

Roof runoff usually contains less pollutants than driveway runoff and provides a great opportunity for water re-use. Rain barrels are excellent ways to conserve water and re-use to water garden beds. The size of the rain barrel can vary as proper rain barrel installation includes an overflow bypass when rain events are greater than that of the rain barrel capacity. However, learning just how much runoff your roof can produce, can be interesting and overall increase one's awareness of stormwater runoff within the home landscape. This section includes links to calculate roof runoff and are intended for informational purposes only.

New Castle County provides YouTube video links on their website for rain barrel installation tips
https://www.nccde.org/1828/Install-a-rain-barrel

Companies that sell large cisterns often provide runoff calculators to help sell their products. An example from another site is also provided as an explanation for the background math the company site calculator is performing.
https://www.watercache.com/resources/rainwater-collection-calculator
http://www.friendsoflittlehuntingcreek.org/description/roof.htm#:~:text=To%20calculate%20the%20runoff%20from%20any%20given%20rainfall%3A,144%2C000%20cubic%20inches%20of%20water.%29%203%20%20

Another way to mitigate roof runoff is by implementing a vegetated green roof. A vegetative green roof is usually not feasible on residential homes but could be an option for a shed or other exterior structure, such as a carport. Due to the potential dangers for serious injury or death due to overloading a roof structure, green roofs should only be implemented by a professional contractor.

3. Home

There are many things we do around our homes that we don't realize contribute to water quality impairments throughout the watershed. The Delaware Department of Transportation provides a good overview of ways our daily habits can improve stormwater management. The link provided is to a brochure prepared for Kent County, however an identical one was prepared for New Castle County but is no longer available as a website link.
https://deldot.gov/Programs/stormwater/pdfs/DelDOT_Brochures_FINAL%20Kent.pdf .

Sump pumps also provide opportunities to mitigate water quality impairments. Designed to take water away from the house, if a sump pump is in use, it is likely that promoting stormwater infiltration upslope or near the building structure(s) is **not** a good idea. However, promoting infiltration farther out from the dwelling is suggested. During a site visit on a sunny day for which it hadn't rained in several days, water was observed flowing down a street side valley gutter. Upon following the flow, it was assumed the discharge was generating from a home sump pump or other drainage pump. The flow was not followed downstream but it's likely this flow was entering the storm drain network.

Regardless if it is as simple as replacing a patch of lawn with a few shrubs or as large has replacing an entire driveway with permeable pavers as this leaseholder has done, every drop in a watershed counts and the cumulative effect of leaseholder initiatives can have a very big impact downstream.

This image was taken on August 5, 2020 around 9:45am, shortly after the remnants of hurricane Isaias came through the area. The introductory image on page 2 of this report was taken at the same time.

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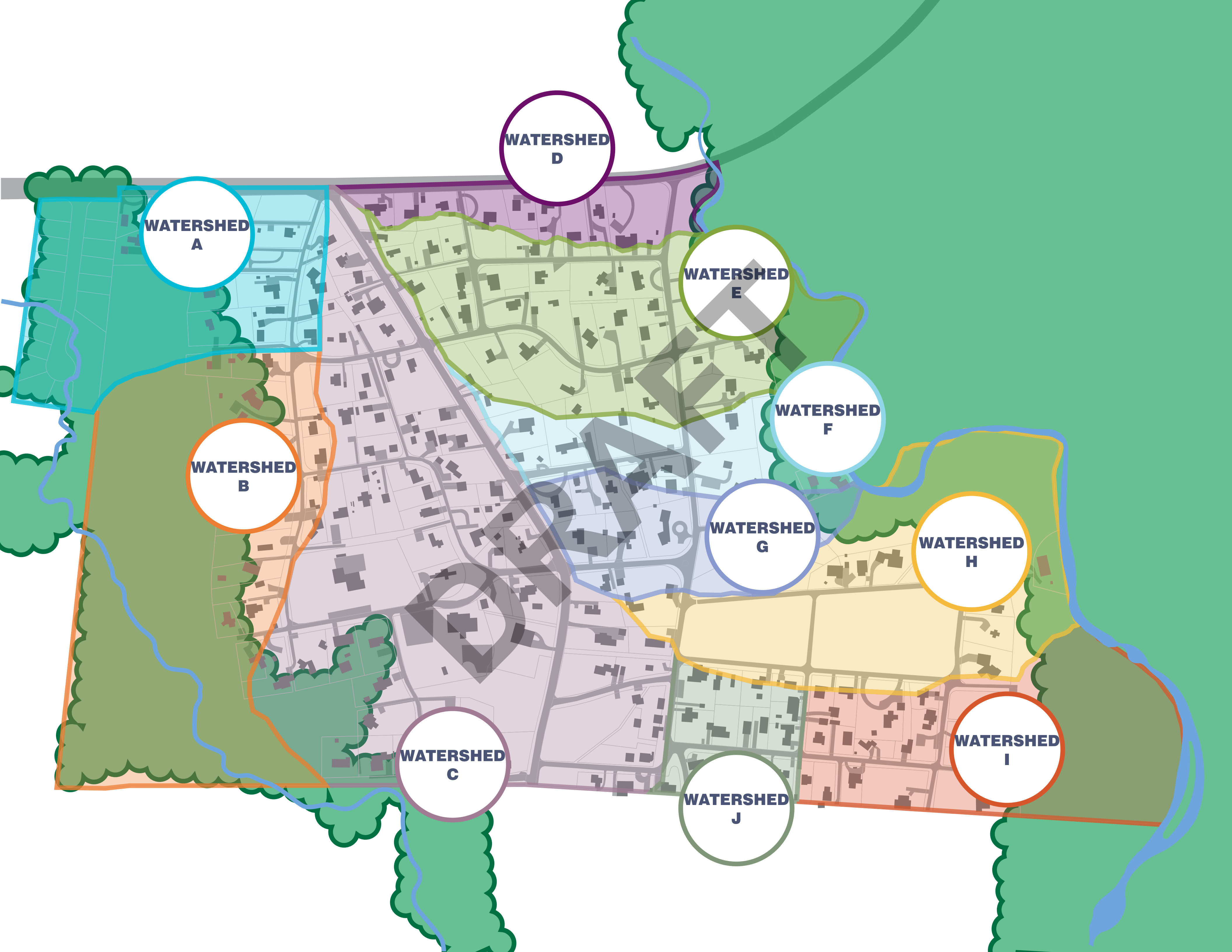
4.2 VILLAGE SCALE OPPORTUNITIES

This portion of the master plan provides further analysis of potential best management practices (BMPs) within each of the identified sub-watersheds. Each recommendation ranges in complexity based on location and access to existing infrastructure, to evaluate the recommendations for safe overflow conveyance. Where feasible, interventions utilized common lands however some are recommended on leaseholder lands. It is important that each conceptual BMP narrative be understood for its contribution to water quality impairments and not only from an estimated implementation cost. The recommendations at the end of this master plan provide a comparison based on factors identified within this section. Each narrative includes minimal utility conflict information. The appendices include FOIA information requested and received from Delmarva, Suez Water, and NCC Sanitary Sewer. Due to delays for security checks to receive the information this information was not able to be fully evaluated for the recommendations. Utilities can be moved for construction but it is an additional cost that might be considered during the review of this plan.

* For all estimated costs, the numbers provided are for the facility construction only and provided for comparison purposes. The costs were created by referencing the “Methodology for developing cost estimates for Opti-Tool”, which can be found in the appendices section, and adding modifiers to reflect more current costs. (This document was created by the EPA and was retrieved as a reference in the Christian River Water Quality Improvement Plan, also available in the appendices.) None of the estimates include necessary design, permitting, drainage construction, required pretreatment or an other costs beyond the physical components within the footprint of the facility described. For example, estimated costs for a bio-retention are based only on the footprint size, depth, approximate stone, media, vegetation, and underdrain pipe with no connections. The appendix section includes the DNREC BMP manual, this should provide further explanation of the physical components for each facility described. For bio-retention facilities a minimum cost of $20,000 was utilized for small facilities.



WATERSHED A
WATERSHED B
WATERSHED C
WATERSHED D
WATERSHED E
WATERSHED F
WATERSHED G
WATERSHED H
WATERSHED I
WATERSHED J
DRAFT

4.2.a WATERSHED A

The area for watershed A equates to approximately 15.5 acres. Approximately 14.2% of this watershed is covered by impervious surfaces. Within the headwaters of the Arden boundary, the watershed exhibits minor drainage concerns within it's direct watershed boundary that would effect water quality; however, water quality BMPs installed within this watershed could assist in improving downstream water quality impairments. Implementation suggestions within this watershed would primarily work to aid in reducing downstream watershed concerns.

Marsh Road is a contributing factor of this watershed but only the southern portion is hydrologically connected to lands of Arden and included in this plan; the northern portion and an unknown boundary to the west connect hydraulically via a five catch basins drainage network to this watershed. The contributing drainage area to these five catch basins, which lies beyond Arden limits, were not evaluated. The outfall into the Arden lands was reviewed for channel stability. As illustrated in the contours there are two swale formations in the area; based on field observations, one is from the outfall and the other is suspected to be the stream corridor prior to Marsh Road being built where the natural ground water surfaces. Both locations show prior evidence of erosion but currently appear stable; where they join together shows mild erosion. This mild erosion should be monitored and preventative measures taken as feasible. Due to the mild nature of the erosion this document recommends utilizing volunteer labor to implement traditional low-impact stream restoration practices; the appendix section contains resources for stream restoration practices, low-impact describes those that utilize vegetation and only rock that is feasible to be carried by the average person, such as a bucket of small rip rap.

The watershed has two main roads directing stormwater runoff through Arden, Avery Lane and Sherwood Road. Avery Lane is limited to this watershed and Sherwood Road connects to adjacent watersheds. During a site visit, it was observed that the fire road connected to Avery Lane is likely providing some level of water quality mitigation by serving as a restriction, a "speed bump" of sorts, for the stormwater runoff flowing from Arden lands, slowing its flow down to Perkins Run. It was observed that the woodlands behind the last house on the east side of the Avery Lane (2037) appears to be changing plant communities. Several upland trees were declining and more hydric (water) loving shrubs species were colonizing. The fire road culvert is likely assisting in limiting the erosive storm flows to the creek thus improving water quality by allowing time for sediments to settle out prior to reaching the stream corridor. It is recommended the fire road be maintained in its current state and breaks, pipes, or other activities that would increase drainage from the east side of the site be removed or repaired to maintain its current state of flow. In the area behind 2037, where more light is reaching the ground level with decreased canopy cover, adding floodplain plantings such as Cornus racemous and Ilex verticillata may help in reducing invasive species colonization and increase ecosystem services provided by wetland plant communities.

Sherwood Road provides the most opportunity in this watershed to improve water quality by directly treating portions of the impervious cover. The road appears to be crowned for most of its length, directing water to both sides. The east side of the road has a concrete gutter, the west side does not. There are two catch basins, one to each side, at the bottom of the steepest road gradient. The east catch basin connects underground to the west catch basin, a plastic pipe carries the run-off underground through leaseholder land and outfalls into Sherwood Forest. After the catch basins, the road appears to have little slope, such that stormwater might not drain well from the road, particularly on the west side where there is no gutter to define the drainage flowpath. The observed roadway crackling, possible road base failure due to saturation, appears to support this assumption. If the catch basins are not kept clear of debris this may add to any areas of slow draining stormwater.

The best opportunity to treat water quality along Sherwood Road for this watershed and aid in slowing the storm surge to the lower watersheds within Arden, is to install bio-retention garden A1 at the intersection of Sherwood Road and Hillside Road. The location is illustrated with a purple circle in watershed map. An intervention in this area could treat some or most of the area highlighted in light blue, an impervious area of approximately 0.48 acres, reducing overall effective impervious cover to 11.1%.

1

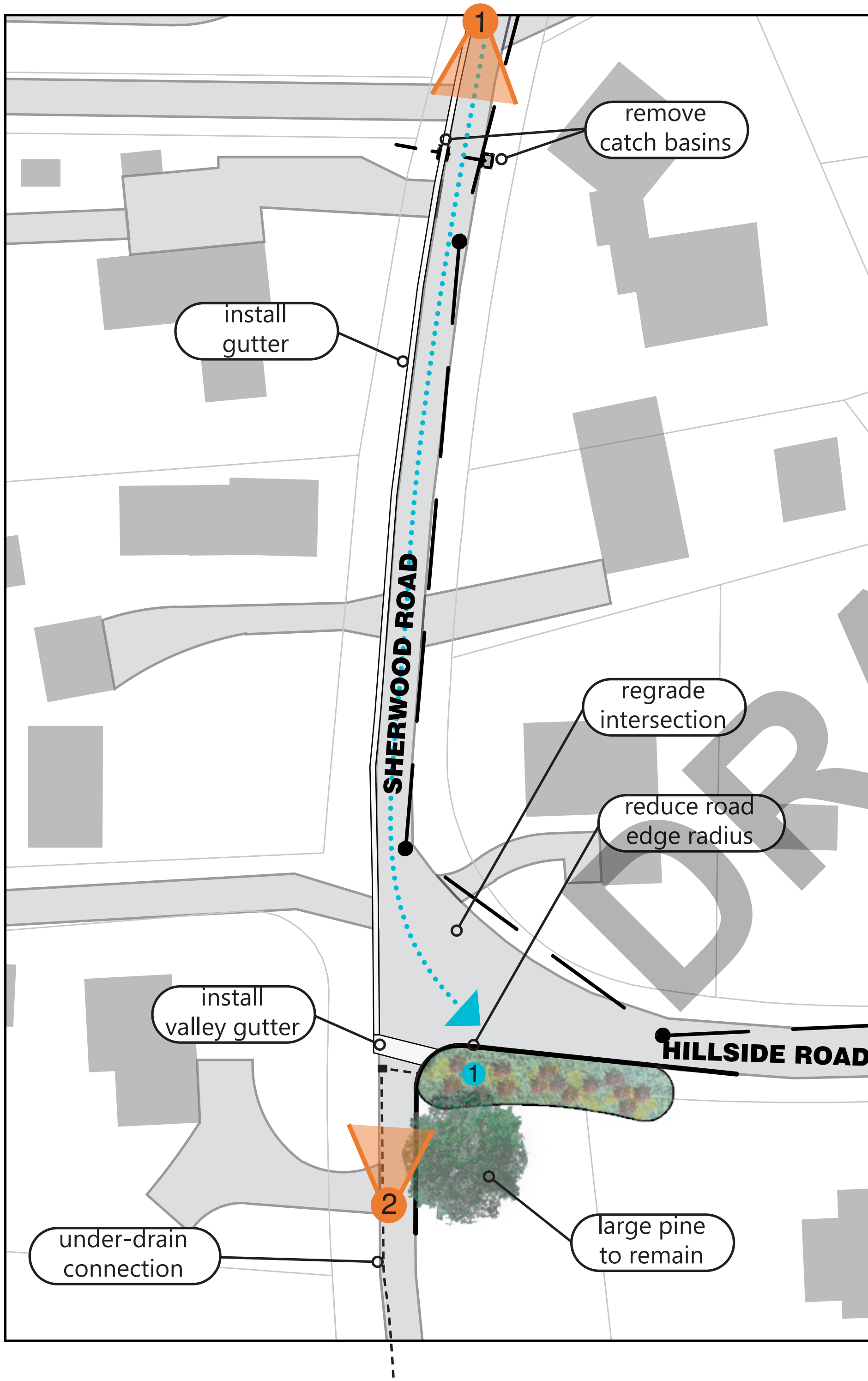
Sherwood Road looking south toward Hillside Road.

The image to the left shows the concrete gutter along the east side and no curb treatment along the west side. The catch basins in this image do appear to have leaves and debris preventing maximum drainage. The reduced drainage through these catch basins could be aiding in the reduction of erosive forces at the pipe outfall. It is suspected some, if not the majority of road runoff, bypasses these catch basins and continues downstream. The outfall should be monitored for erosion after cleaning of the storm drains.

2

North view of Sherwood Road and Hillside Road intersection.

The wet soils and crackling pavement imply stormwater may not drain well from the roadway in this area. Site observations suggest when road runoff gets to this intersection there is no defined drainage path. Factors likely contributing to the lack of defined drainage include a slight curb on the north side of the island creates a dam effect where water likely puddles, and on the east side of the road the concrete gutter ends prior to the intersection leaving and undefined flowpath for upslope road runoff.



To assist in treating water quality and reducing storm surge downstream, it is suggested a bio-retention garden be installed in an area of paving removal. The proposed system suggests removing the catch basins and speed bump to ensure road run-off reaches the garden, installing a concrete road gutter on the west side of the road to direct drainage to this location, repairing the east side gutter as needed, and installing a concrete valley gutter to direct water across the road and into the garden. It is recommended the intersection have a reduced radius on the south side and the existing island be paved, to provide area for the BMP and vehicle maneuvers. The entire intersection from the end of Watershed A should be re-graded to slope to the garden, as illustrated with the dotted blue line arrow. Given the lack of sewer infrastructure and the existing downstream catch basin network, it is likely feasible to connect the bio-retention garden's under-drain and overflow system to the existing storm drain network at the intersection of Lover's Lane. The large pine is assumed to have more of its root structure growing towards the open grass areas and not toward the existing road. It is anticipated in this plan to remain; it is strongly suggested a certified arborist be contacted as required to protect the tree during construction.

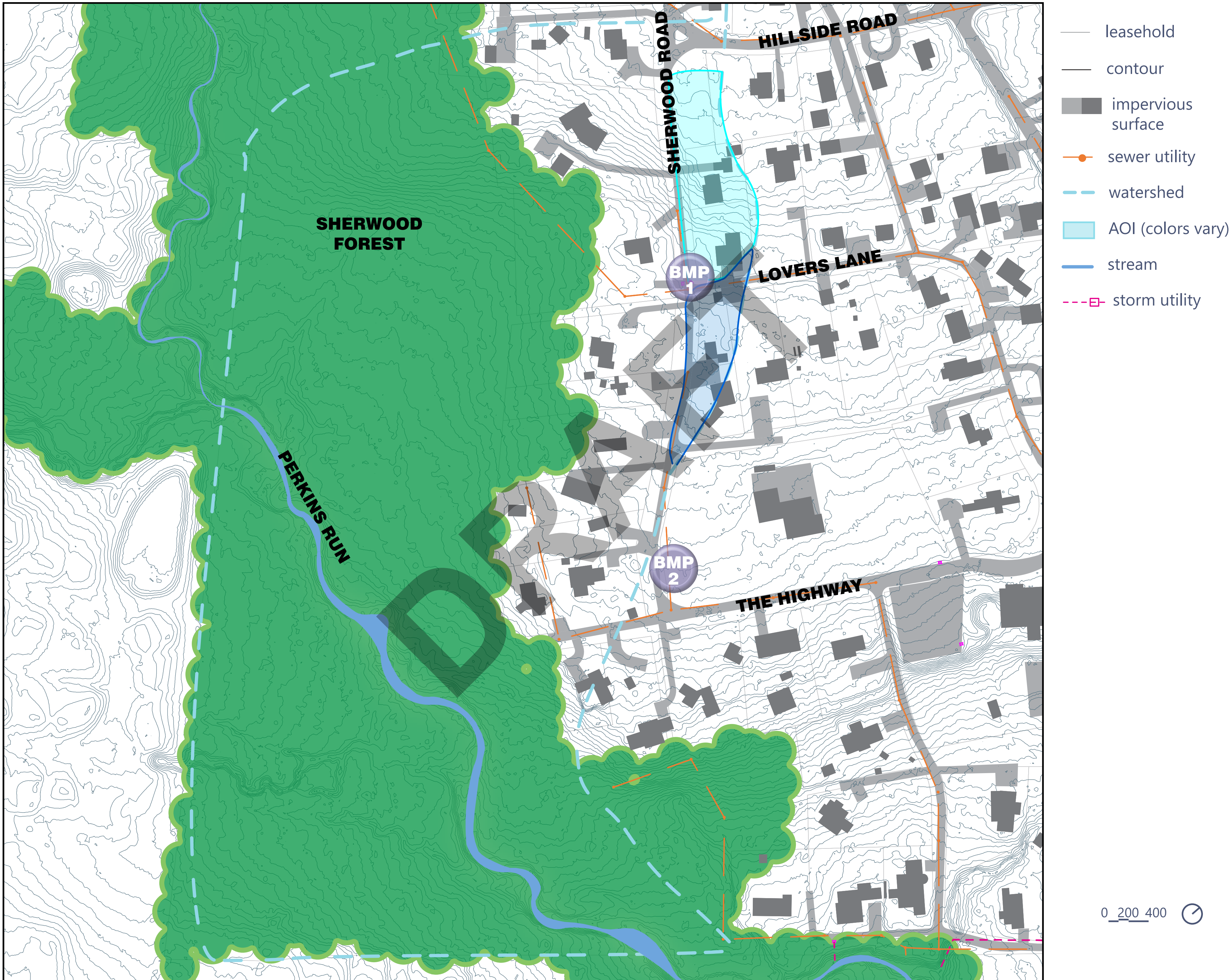
The drainage area for the garden is ~49,685 sf. The impervious area within this drainage area is ~20,859 sf. (42%). A garden footprint as shown for A1 at 2.5 ft deep would support a storage volume of ~1,650 cu. ft. This size would capture the water quality event of 2". Estimated costs for the facility would be $87,750*.

4.2.b WATERSHED B

The area for watershed B equates to approximately 27 acres. Approximately 5.9% of this watershed is covered by impervious surfaces. Sherwood Forest is the primary landscape typology within the watershed. The Arden side of Perkin's run within Sherwood forest appears generally stable. There is one channel that can be seen in the contour patters that ends at the fire road. As explained in the Watershed A narrative, the fire road is likely acting like a "speed bump" and preventing faster stormwater flows generated by the upstream impervious surfaces within Arden from negatively effecting Sherwood Forest and Perkins Run. Unfortunately, the other side of Perkins Run is not stable. In several locations along the stream, eroded channels can be observed within the forest generating from the adjacent neighborhoods; most of the channels originate on property outside Arden lands. Restoration of these channels are likely to need structural components and should be undertaken by a design professional.

To reduce water quality impairments due to unmanaged stormwater runoff, this plan suggest the implementation of two BMPs, one within the watershed boundaries and one in Watershed C but treating impervious coverage within Watershed B. The first suggestion would be bio-retention garden B1 at the intersection of Lovers Lane and Sherwood Road. At this intersection, visual evidence suggests water ponds on the east side catch basin for unknown reasons, perhaps frequent grate clogging and/or insufficient road slope. The second catch basin outfalls into leaseholder land. Being an existing low point where there is existing drainage infrastructure in place increases the feasibility of this location for water quality initiatives. The garden would intercept the overland flow downstream of the proposed bio-retention garden in Watershed A at Hillside Road. Similar to Watershed A, the crowned topography of Sherwood Road continues through this watershed. Gutters are suggested to be installed on both sides of Sherwood Road to aid in drainage and direct water to the proposed garden. Unlike Watershed A, the intersection is more narrow and space for improvements is limited. According to public data, there does appear to be room to fit a facility within common land, however images of the area suggest landscaping may need to be removed for implementation; the boundary between common land and leaseholder land will likely need to be discussed prior to any construction drawings prepared for implementation. The location is illustrated with a purple circle in watershed map. An intervention in this area could treat some or most of the area highlighted in light blue, an impervious area of approximately 0.17 acres, reducing overall effective impervious cover to 5.3%.

The second BMP suggestion is to utilize the common open space within lands of the Buzz Ware to implement a bio-swale, B2. There are specific design criteria that classify a bio-swale versus a vegetative swale with a bio-swale providing a higher level of treatment. For the purposes of this narrative, the term bio-swale is used as a general term for a vegetated swale. Gutters could be installed to each side of Sherwood Road south of the Lovers Lane intersection. A valley gutter crossing Sherwood Road would direct both gutters to the start of the bio-swlae in the open space south of the Sunset Road intersection. A visual assessment of this area shows several rocks and a sewer access cap. These constraints may hinder the implementation of a BMP in this area, but the potential for it to treat road runoff for water quality impairments warrants its inclusion in this plan. If a bio-swale can be implemented, an outfall location would need to be identified; an option is discussed in Watershed C BMP 4, for the potential for the area to connect via a bio-retention garden to that system. If a garden does not fit potentially a catch basin system may be an option for further outfall analysis. The location is illustrated with a purple circle in the watershed map. An intervention in this area could treat some or most of the area highlighted in deep blue, an impervious area of approximately 0.22 acres, reducing overall effective impervious cover to 5.1%.



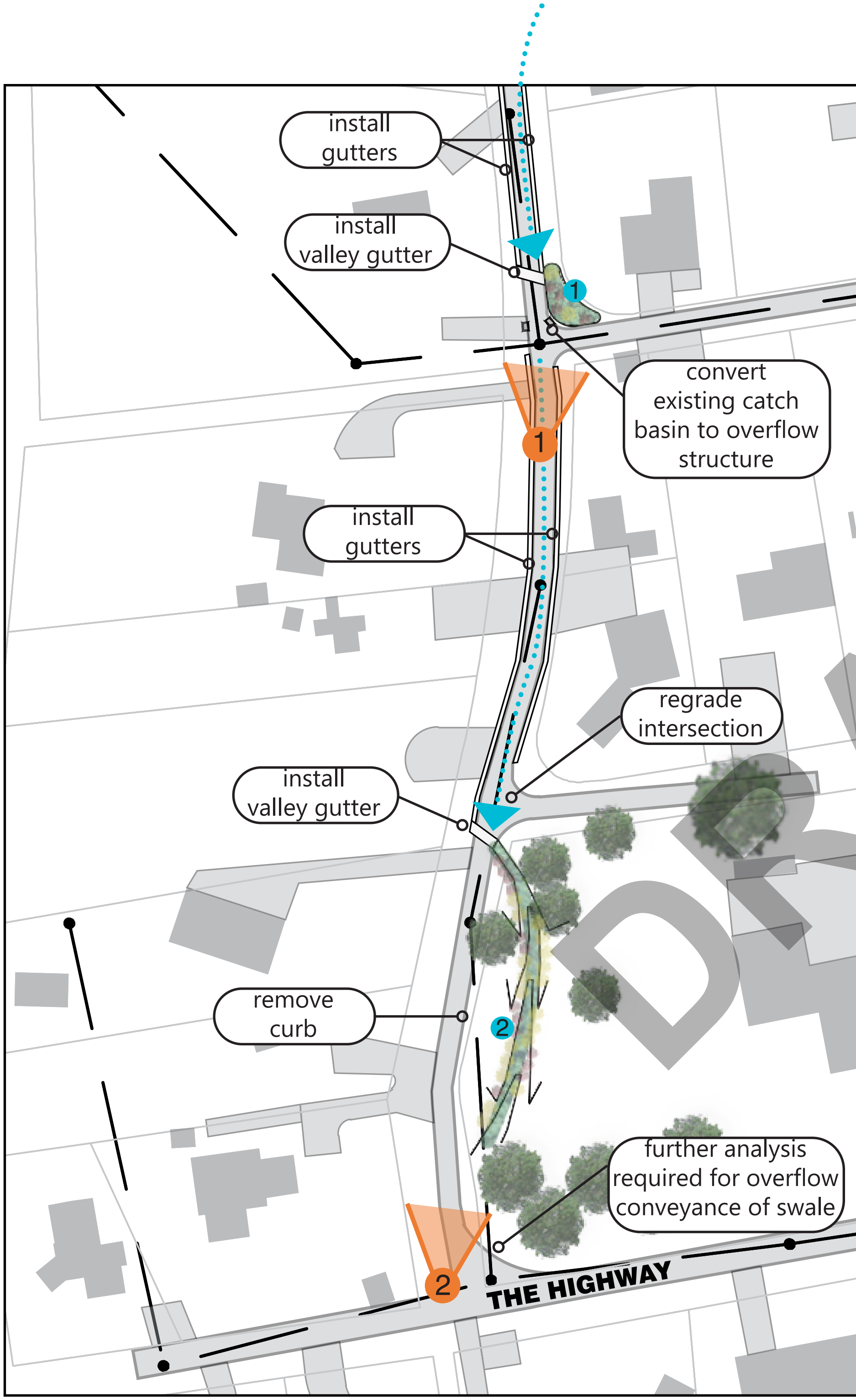
HILLSIDE ROAD
SHERWOOD ROAD
SHERWOOD FOREST
LOVERS LANE
BMP 1
BMP 2
PERKINS RUN
THE HIGHWAY
leasehold
contour
impervious surface
sewer utility
watershed
AOI (colors vary)
stream
storm utility
0 200 400

1
North view of Sherwood Road and Lovers Lane intersection.

The image to the left shows the northeast intersection where the implementation of a bio-retention garden is suggested. There is a visible sewer manhole at the center of the intersection but the existing catch basins suggest introducing a water quality facility is feasible. Depending on where the boundary is between leaseholder land and common land, the visible hedgerow may need adjustments.

2
Sherwood Road looking north toward Sunset Road.

The image to the left shows the granite block curbing along the Buzz Ware side of Sherwood Rd. The topography along with dirt and debris collecting at the curb line suggests channelized flow along the curb line. Removing the curb would encourage pollutants and sediment to dissipate into open space, rather than being transported downstream. The introduction of a bio-swale / vegetative swale would increase the water quality treatment of Sherwood Road.



To assist in treating water quality, it is suggested a bio-retention garden and a bio-swale be installed to treat unmanaged stormwater from Sherwood Road. The bio-retention garden should be installed within the common lands at the intersection of Lovers Lane. Concrete gutters should be installed to each side of the road to direct water to the garden. The west side gutter will need a valley gutter or trench drain to cross over Sherwood Road to direct the stormwater into the proposed garden. The existing catch basin should be modified to meet overflow and under-drain requirements as needed. After the bio-retention garden the concrete gutters should continue to direct water to the Sunset Road intersection. The gutters should run adjacent to the existing speed bump and a valley gutter installed across Sherwood Road to direct the water from the gutters to the swale. The intersection should be re-graded to direct water from both roads to flow into the common lands of the Buzz Ware. The curb along the Buzz Ware open lands should be removed to encourage water into the open space and bio-swale. At the feasibility level there is no identifiable outlet location for the bio-swale, Watershed C BMP 4 suggests a possible connection but it is limited in its analysis. Future construction level investigations will be needed to determine the opportunity to implement a bio-swale with the visible constraints in the form of trees, rocks, and utilities, as well as safe conveyance at the end of the swale.

The drainage area for the garden is ~36,775 sf. The impervious area within this drainage area is ~7,400 sf. (20.1%). A garden footprint as shown for B1 at 2ft deep would support a storage volume of ~315 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $20,000*.

The drainage area for swale B2 is ~21,535 sf. The impervious area within this watershed is ~9,580 sf. (44.5%). The swale illustrated is approximately 1ft deep and 200ft long with a 3ft bottom width and 4:1 side slopes. The swale requires further design to fully evaluate but it is likely to treat 50% of the water quality event .and estimated to cost $10,000 depending on potential conflicts.

0 125 250

4.2.c WATERSHED C

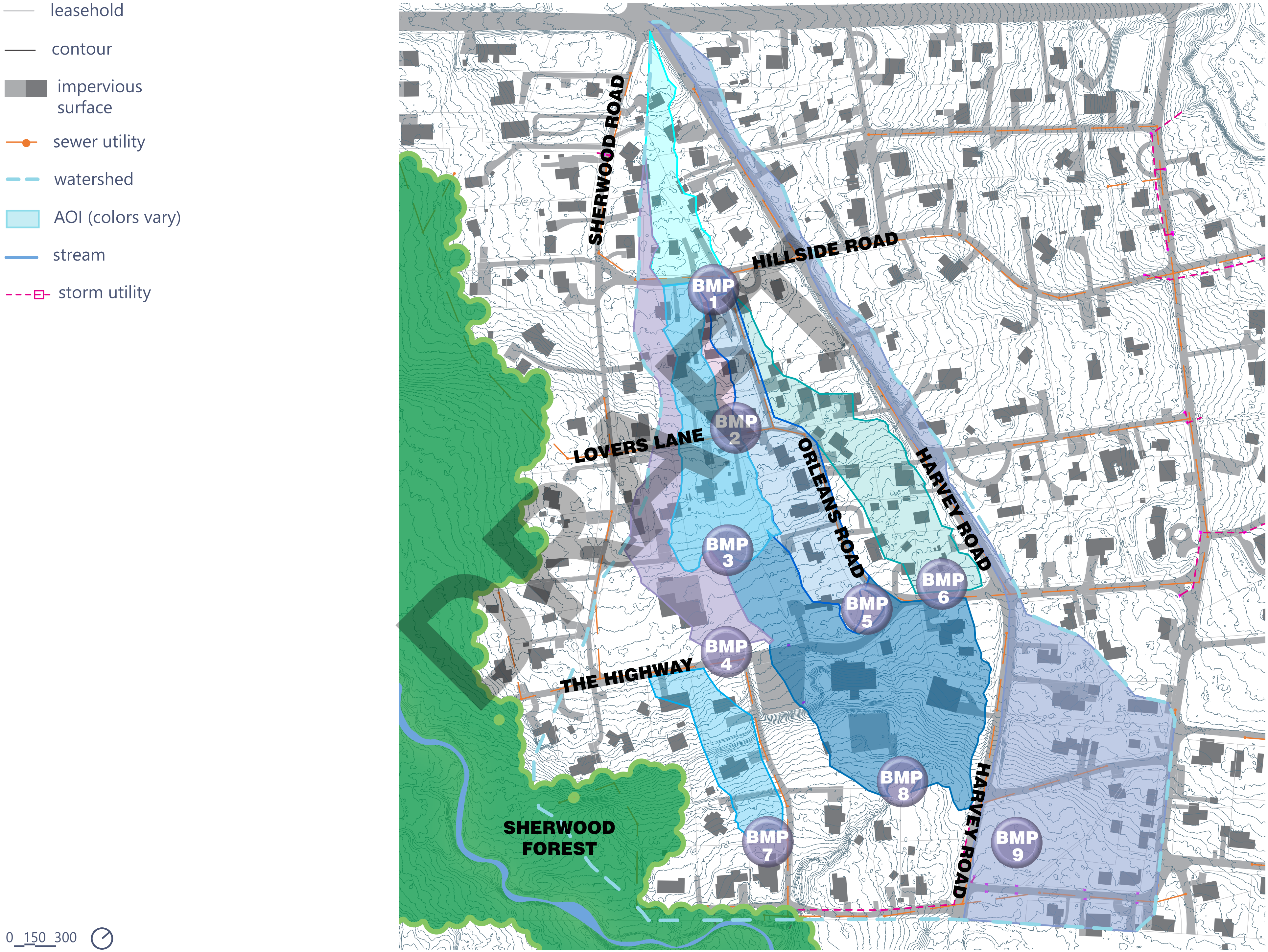
The area for watershed C equates to approximately 39.5 acres. Approximately 24.1% of this watershed is covered by impervious surfaces. The storm flows through this watershed generally travel in a southern direction. This is the largest watershed within Arden and the third largest in percent impervious cover. Watershed D and J have a higher percent impervious but as noted in the synopsis, J is connected to C via a storm drain network, so it can be said it is the second highest in percent impervious. In addition to being the largest and one of the most impervious watersheds, it also has the longest direct connections from the top of the watershed to the bottom of the watershed. The recommendations for this watershed would be the same for all others, to capture and slow water higher up in the watershed; given the length of storm flows through this watershed this methodology will assist in reducing downstream drainage concerns. With this concept in mind, nine (9) BMPs are suggested within the watershed and illustrated with a purple dot.

BMP 1 - # 2118 Hillside Road appears to be roughly 38% impervious coverage with a dwelling, garage, and several loosely structured parking areas. It is suggested the upper parking area be removed and transitioned to a bio-retention garden. Internet imagery suggests that a re-design of the parking area along Orleans Road could create a more efficient “courtyard” style driveway and a more efficient layout could create additional area that would make up for the space removed for the proposed stormwater feature. With limited drainage infrastructure in the area, safe overflow conveyance would need further evaluation. An intervention in this area could treat some or most of the area highlighted in blue above BMP 1, an impervious area of approximately 0.23 acres, reducing overall effective impervious cover to 23.5%

BMP 2 - This BMP proposes to transition the parking area between 2117 and 2119 Lovers Lane to porous paving. The watershed to this parking area is small but it appears to capture enough impervious coverage to provide water quality benefits. The change from gravel to porous paving will also assist in reducing the transport of loose driveway gravel material during rain events, reducing sediment deposition into the downstream watersheds. For an added water quality benefit, this location could also utilize a cistern underneath the paving to capture more water. An intervention in this area could treat some or most of the area highlighted in pink above BMP 2, an impervious area of approximately 0.09 acres, reducing overall effective impervious cover to 23.9%

BMP 3 - Taking advantage of open space on non-leaseholder land, this BMP is suggested on lands of the Buzz Ware Center but topographically at the top of the open space, to provide water quality treatment to the landscapes uphill of the Buzz Ware. This BMP can be an open detention pond or a bio-retention garden; it is being described in this plan as a bio-retention garden which provides greater pollinator habitat value compared to a detention pond. The facility design should maximize space while preserving existing tree canopy. An intervention in this area could treat some or most of the area highlighted in turquoise above BMP 3, an impervious area of approximately 0.32 acres, reducing overall effective impervious cover to 23.3%

BMP 4 - Two BMPs in this area are proposed; one, to transition the parking area for the Buzz Ware to porous paving and the second to add a bio-retention garden in the open space at the front of the Buzz Ware parcel. The bio-retention garden will capture the majority of impervious runoff from the sports court. This bio-retention garden will also capture run-off from the Buzz Ware building but it is suggested additional BMPs such as rain barrels be added to the building as an example of best management practices for Arden residents to emulate. Although not directly connected to this area, the design also suggests a bio-retention garden to the west of the Buzz Ware parking lot. The feasibility and hydrologic connections between the Buzz Ware parking lot and Watershed B’s bioswale should be evaluated during the construction design process. The two interventions in this area could treat some or most of the area


leasehold
contour
impervious surface
sewer utility
watershed
AOI (colors vary)
stream
storm utility
0 150 300
SHERWOOD ROAD
HILLSIDE ROAD
LOVERS LANE
ORLEANS ROAD
HARVEY ROAD
THE HIGHWAY
HARVEY ROAD
SHERWOOD FOREST
BMP 1
BMP 2
BMP 3
BMP 4
BMP 5
BMP 6
BMP 7
BMP 8
BMP 9

highlighted in purple above BMP 4, an impervious area of approximately 0.8 acres, reducing overall effective impervious cover to 22.7%

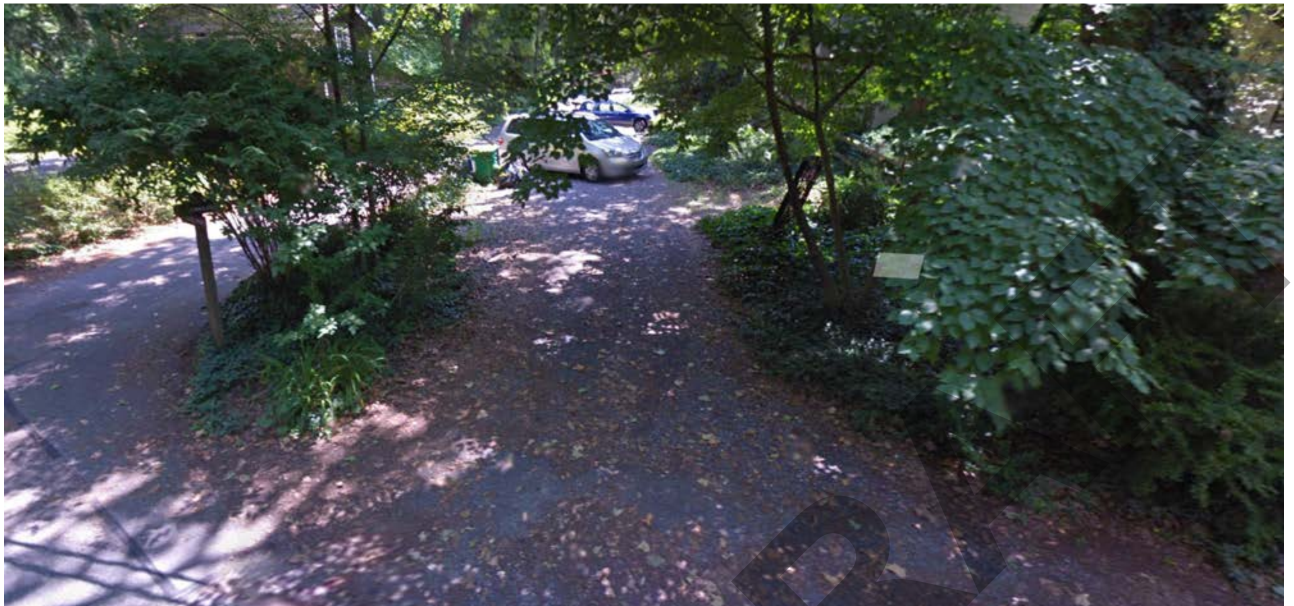
BMP 5 - The boundary between Arden and leaseholder land is unclear for 2123 The Highway. For the purposes of this plan it is assumed within Arden open space. The location is ideal for a detention or bio-retention garden to reduce stormwater flows originating down Orleans Road and settling in front of Gild Hall where it is drained by a road catch basin. The majority of run-off from Orleans Road turns at this intersection and drains down to The Highway, a BMP here would treat a considerable amount of untreated impervious surface within the watershed. An intervention in this area could treat some or most of the area highlighted in blue above BMP 5, an impervious area of approximately 0.65 acres, reducing overall effective impervious cover to 22.4%

BMP 6 - This is located on lands of the leasehold known as The Doll House. Currently this appears to already be a low point in the topography that collects water during rain events. This BMP is a suggestion to give the water a defined space to collect and then a safe overflow location, rather than the current spill-over onto Orleans Road. Unlike many of the watersheds reviewed for this plan, this watershed appears to lack contribution from a roadway. The run-off is likely all from roof, driveway, and other leaseholder amenities. Besides a defined BMP location this watershed would greatly benefit from leaseholder initiatives such as porous paving, rain barrels, and native plantings to reduce lawn area and increase vegetative water uptake. An intervention in this area could treat some or most of the area highlighted in blue above BMP 6, an impervious area of approximately 0.66 acres, reducing overall effective impervious cover to 22.4%

BMP 7 - The topography in this area suggests water runs downhill directly to 2117 Meadow Lane. A site visit confirmed this is largely true and the leaseholders have done a number of drainage interventions to prevent the run off from flooding the dwelling. The system appears to work but largely consist of gray infrastructure. This BMP is suggested on the leasehold of 1806 Pond Road. The BMP should be located in the open area near the fence bordering the two leaseholds, this plan does not suggest taking down any mature trees in the landscape. The introduction of a bio-retention garden will allow for water quality improvements in addition to aiding in drainage concerns downstream. The overflow connection to the existing stream course appears feasible. An intervention in this area could treat some or most of the area highlighted in blue above BMP 7, an impervious area of approximately 0.22 acres, reducing overall effective impervious cover to 23.5%

BMP 8 - This BMP utilizes the open space in the Memorial Garden. Currently there is an oval shaped depressed area with a stone curb around it. Pipe holes in the ground were observed in the area that suggest the area may have a drainage system within the footprint. The watershed for this BMP largely consists of the impervious area of Gild Hall, its surrounding pathways, a portion of its parking lot, the pool, and pool decking. An intervention in this area could treat some or most of the area highlighted in blue above BMP 8, an impervious area of approximately 1.28 acres, reducing overall effective impervious cover to 20.8%

BMP 9 - Harvey Road is the main north-south corridor that leads through Arden. The watershed for the length of Harvey Road within Arden appears to be limited to Arden lands. This conclusion is based on the topographic highpoint at the intersection of Marsh and Harvey Road, the crowned topography of Marsh Road, the catch basin network along Marsh Road that enters Perkins Run to the west, and the low point along Marsh Road to the east that directs run-off to Naamans Creek prior to it entering Arden lands. As a through-street, Harvey Road is the only non-Arden maintained road within the its limits. It is also wider and has the longest continuous flow path over an impervious surface. It is suggested a further study be done in conjunction with DelDOT to determine opportunities to increase the drainage infrastructure along this roadway and increase water quality opportunities beyond the “bottom of the watershed”. It is our understanding there may be some hesitancy on the part of Arden to engage in conversations with DelDOT, as improvements may lead to widening the road which would likely increase vehicular speeds through Arden, and increase impervious surfaces. The authors of this plan fully acknowledge this argument and are sensitive to the concerns that it might negatively segregate the Arden and increase hazardous conditions for pedestrians. However, short of additional drainage infrastructure upslope in the watershed, the east side of the Memorial Garden appears the only feasible place to implement a BMP facility. Based on the visibility of several surface expressed boulders in the area, in addition to the preference for the area to continue to function as a Memorial Garden to some degree, this plan recommends a geotechnical evaluation to assess the extent of bedrock in the area prior to any further BMP design within the area.



1
Hillside Road looking south at the intersection of Orleans Road, which is shown on the left side of the image.

This corner leasehold has a large percent of impervious coverage and the parking areas appear they could function with less of a footprint if designed in a courtyard style. Making the parking area off Orleans Road more efficient could transition this area to be used for a BMP 1.

2
Lovers Lane looking north.

Many stone driveways exist in Arden and contribute to sediment loading as small particles wash away with storms and general wearing from vehicular traffic. This driveway has a mild slope and would be a good location to convert to porous materials for BMP 2. As costs permit a storage reservoir could be incorporated below to increase run off reduction to downstream areas.

3
End of Sunset Road looking northeast toward Orleans Road

Working around existing trees, this area provides open space to implement a bio-retention garden to capture upslope drainage for BMP 3.

4
The Highway looking at the Buzz Ware parking area.

Transitioning this lot to porous material for BMP 4, can aid in reducing the runoff to downstream properties and headed southwest to Perkins Run.

5
The Highway looking southeast toward the Buzz Ware.

The trees in this location appear to be either declining or non-native species. For BMP 4, it is suggested to remove them, install a bio-retention garden to capture run-off from the Buzz Ware and the associated sports courts / fields. New native trees can be incorporated into the design.

6
Orleans Road looking east, The Highway is the road in the background.

Utilizing the open space to the right of the image for BMP 5, would provide an area to treat the majority of impervious cover of Orleans Road.

7

Orleans Road looking north at the Doll House leasehold.

This picture was taken shortly after tropical storm Isaias came through the area. BMP 6 could be implemented within the areas that are already topographical low points in the lawn.

8

Pond Road facing west looking at the southern edge of 1806 Pond Road.

With care taken to reduce impacts to the existing trees, BMP 7 could be constructed in the open lawn area near the fence. In this picture that area appears brown in color.

9
Memorial Garden looking northeast.

The existing open area at the base of the stone wall provides a large area to treat run-off prior to it joining the rock lined channel that leads to an eroded outfall at Perkins Run. BMP 8 proposes to transition this area to a bio-retention garden.

10
Memorial Garden looking northeast.

During a site visit running water could be heard in a PVC pipe opening at the edge of the wall along the north edge as shown in this image. The spring house may be hydraulically connected to the open area and further investigations needed prior to the design of BMP 8.

11

Harvey Road looking north into east extension of Memorial Garden.

This is the largest area of open space nearest to one of the heaviest areas of run-off. Further investigations are required for the feasibility of BMP 9 in this area.

Implementation of the BMPs proposed for Watershed C to assist in treating water quality and reducing storm surge downstream, is summarized below. The call outs on the map in the following pages provides a summary of the descriptions below.

BMP 1 - This facility is being proposed on leaseholder land. This plan suggests removal of the gravel parking area along Hillside Road and reconfiguring the larger parking area along Orleans Road to function as the primary parking area for the residence. Some landscaping should be removed in the area to increase the facility footprint beyond the gravel area. The facility will be a traditional bio-retention garden but it will require curbs with curb inlets to maximize the footprint and extend it to be directly adjacent to Hillside and Orleans roads. A concrete valley gutter will need to be installed to capture road run off at the intersection and re-direct it to this BMP and not continue down Orleans Road. The drainage area for the garden is ~148,900 sf.. The impervious area within this drainage area is ~10,100 sf. (6.7%). A garden footprint as shown at 2 ft deep would support a storage volume of ~1,120 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $59,550*.

BMP 2 - This facility is being proposed on leaseholder land. This plan suggests changing the existing gravel lot to porous paving. Larger storm events could be captured if a cistern was implemented under the paving; it is anticipated the more water that can be captured upstream in the Arden, will aid in downstream drainage concerns. The location of this facility, in addition to the relatively flat topography, comparable to other areas in the Arden, suggest excavation for a cistern system may be feasible however, overflow connections may be difficult and would need further investigations. The drainage area to this paving is ~9,450 sf. The impervious area within this drainage area is ~4,100 (43.4%). A paving footprint as shown at 1 ft deep would support a storage volume of ~600 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the porous paving facility would be $36,950*.

BMP 3 - This facility is being proposed on common land. This plan suggests implementing a bio-retention garden in the open space to the east of Sunset Road; the garden should be designed around the existing mature trees and nestled into the landscape avoiding tree roots. The suggested sizing may need to be modified if the facility cannot be sized as shown due to excavation complications to avoid tree roots, as much as practical. A small swale will be required on the east side to capture some of the drainage area near the leaseholder driveway. It is anticipated this facility can overflow to the existing catch basin at The Highway. The drainage area for the garden is ~86,200 sf. The impervious area within this drainage area is ~13,950 (16.2%). A garden footprint as shown would support a storage volume of ~6,200 cu. ft. This size would capture the water quality event of 2" Estimated costs for the facility would be $329,500*.

BMP 4 - This BMP proposes two facilities on common land which are combined into one narrative as it is assumed they have the potential to connect as needed to maximize the capture opportunities, and for safe overflow conveyance to the catch basin system along the Highway. This plan suggests implementing a bio-retention garden in the open space south of the Buzz Ware and replacement of the existing parking area for the Buzz Ware to porous paving. In the area of the proposed garden the existing trees appear in poor quality or of non-native origin; it is suggested these trees be removed. It is recommended that the design of the new facility integrate new native trees into the adjacent areas. These two facilities will capture the large impervious area generated by the Buzz Ware building, sports courts north of the building, and parking area for the Buzz Ware. Not included in this analysis, but illustrated on the map, is a second bio-retention garden to the west of the porous paving. There appears to be a low point that might aid in capturing the bio-swale from Watershed B and connecting it to this watershed's treatment suggestions. This could provide a safe outfall conveyance for the Watershed B bio-swale. Similar to the bio-swale, the area has visible bedrock and mature tree constraints and thus is being left as a suggestion for further analysis and not included as a design intervention in this plan. The BMPs in this location are the last downslope opportunity on common land to capture water within the western portion of this watershed, any opportunities to treat for both water quality and quantity should be evaluated. The drainage area for these BMPs is ~114,800 sf. The impervious area within this drainage area is ~24,675 (21.5%). A garden footprint as shown at 2ft deep would support a storage volume of ~1,760 cu. ft.; a paving footprint similar to existing at 1ft deep would support a storage volume of 1,000 cu. ft.. These sizes would capture the water quality event of 2" Estimated costs for the eastern bio-retention facility only would be $93,500; the porous paving parking area would be $61,550 for a combined total of $155,050*.

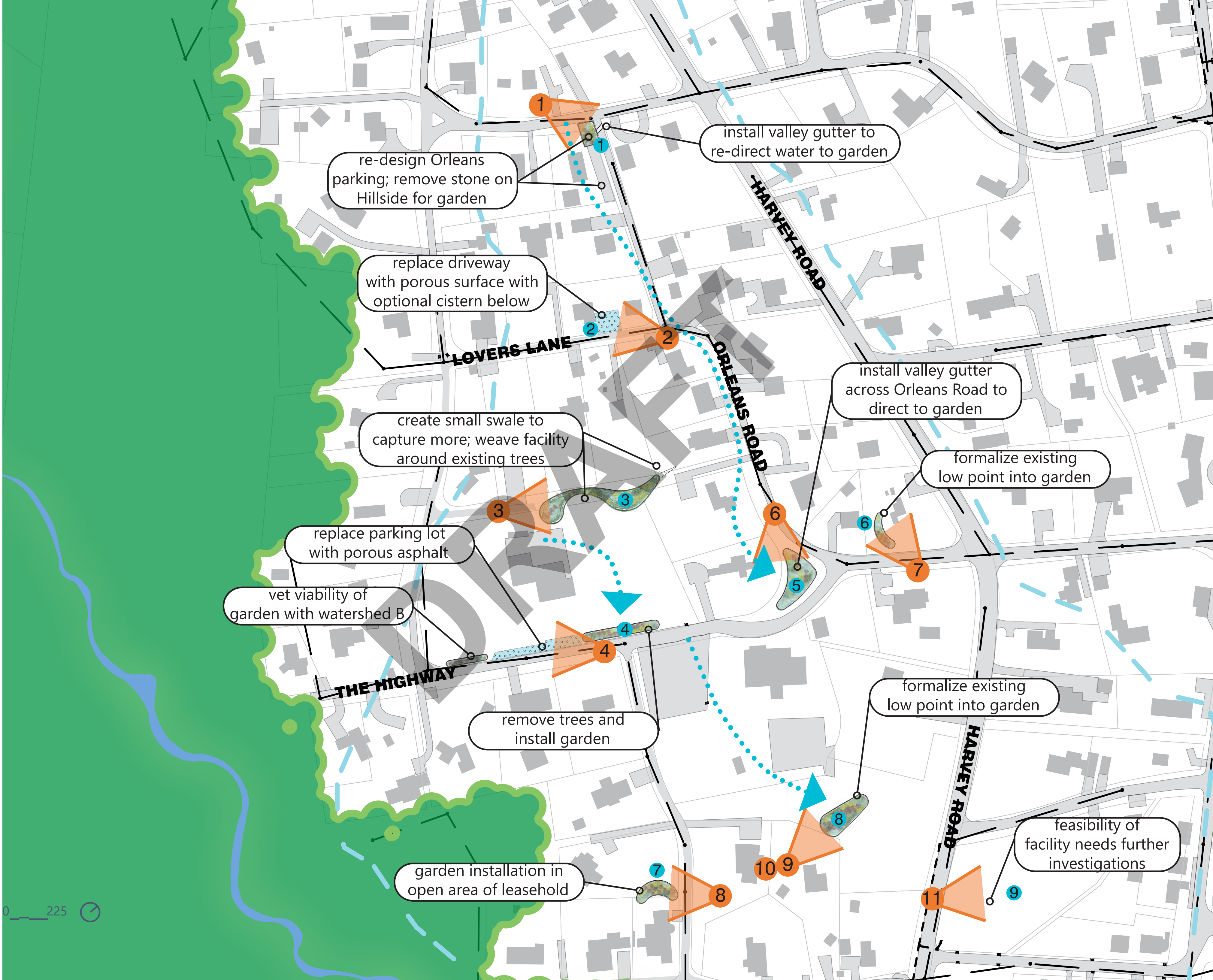
BMP 5 - It is unclear if this facility is on common land or leaseholder land, for the purposes of this plan it will be assumed to be on common land. This plan suggests implementing a bio-retention garden in the open space at the corner of Orleans Road and The Highway. There is existing tree, shrub, ground-cover, and lawn in the location; it is suggested the lawn and ground-cover be removed but the facility should work around any native trees and shrubs. To capture a large portion of Orleans Road a valley gutter or potentially a catch basin system will need to be installed. A hydraulic analysis would be required to see if a valley gutter is sufficient enough or more infrastructure required. The drainage area for the garden is ~96,500 sf. The impervious area within this drainage area is ~28,460 (29.5%). A garden footprint as shown 2 ft deep would support a storage volume of ~1,350 cu. ft. This size would capture the water quality event of 2". Estimated costs for the facility would be $71,700*.

BMP 6 - This facility is being proposed on leaseholder land. This plan suggests implementing a bio-retention garden in the area of the yard that appears to be a low point that currently collects excess run-off. The entire watershed for this garden appears to be comprised of leaseholder impervious with no roads or common lands that contribute to it. This plan strongly suggests the homes in this watershed implement leaseholder scale opportunities as noted in section 4.1. The drainage area for the garden is ~116,700 sf. The impervious area within this drainage area is ~28,900 (24.7%). A garden footprint as shown at 2ft deep would support a storage volume of ~615 cu. ft. This size would capture the water quality event of 2" Estimated costs for the facility would be $32,700*.

BMP 7 - This facility is being proposed on leaseholder land. This plan suggests implementing a bio-retention garden in the area of the lawn on the side of the fence just north of the southern leasehold boundary line. The majority of trees should remain and the facility should be constructed to a size that minimizes damage to existing tree roots. During a site visit the downstream leaseholder had shown the authors a drainage network they had installed of small catch basins to move water around their dwelling. They expressed no flooding to the home but given storm events are projected to increase in intensity and volume with climate change, this facility will likely aid in reducing future flooding. The drainage area for the garden is ~49,700 sf. The impervious area within this drainage area is ~9,600 (19.3%). A garden footprint as shown at 2ft deep would support a storage volume of ~1,870 cu. ft. This size would capture the water quality event of 2".Estimated costs for the facility would be $99,400*.

BMP 8 - This facility is being proposed on common land within the Memorial Garden. This plan suggests implementing a bio-retention garden in the oval area enclosed by a stone wall. The footprint is suggested to stay as is and the depth increased, also, modifications to the area would be required to prevent run-off from bypassing the facility. The existing area has visible pipes and outlets that would need to be modified for a facility to function as intended. If further investigations of BMP 9 don't provide enough storage to improve the drainage along Harvey Road, this location may be able to capture some of the water coming into the upper catch basin. This is not being suggested in this plan as it entails similar constraints as BMP 9 and may be too intrusive for the Memorial Garden landscape; this suggestion is only provided as an option for further evaluation. The drainage area for the garden is ~210,900 sf. The impervious area within this watershed is ~55,800 (26.5%). A garden footprint as shown at 2ft deep would support a storage volume of ~5,100 cu. ft. This size would capture the water quality event of 2". Estimated costs for the facility would be $271,115*.

BMP 9 - This plan suggests further exploration to the viability of a facility in this area. It appears the most viable area on common lands to provide water quality treatment and reduce drainage burdens along Harvey Road at the bottom of the watershed. However, visible boulders suggest excavation for a facility may be cost prohibitive due to the presence of bedrock or could require any facility to be shallow, thus taking up a larger footprint of the garden. Estimated costs unknown.



install valley gutter to re-direct water to garden
re-design Orleans parking; remove stone on Hillside for garden
HARVEY ROAD
replace driveway with porous surface with optional cistern below
LOVERS LANE
ORLEANS ROAD
install valley gutter across Orleans Road to direct to garden
create small swale to capture more; weave facility around existing trees
formalize existing low point into garden
replace parking lot with porous asphalt
vet viability of garden with watershed B
THE HIGHWAY
remove trees and install garden
formalize existing low point into garden
HARVEY ROAD
feasibility of facility needs further investigations
garden installation in open area of leasehold
DRAFT
0 225

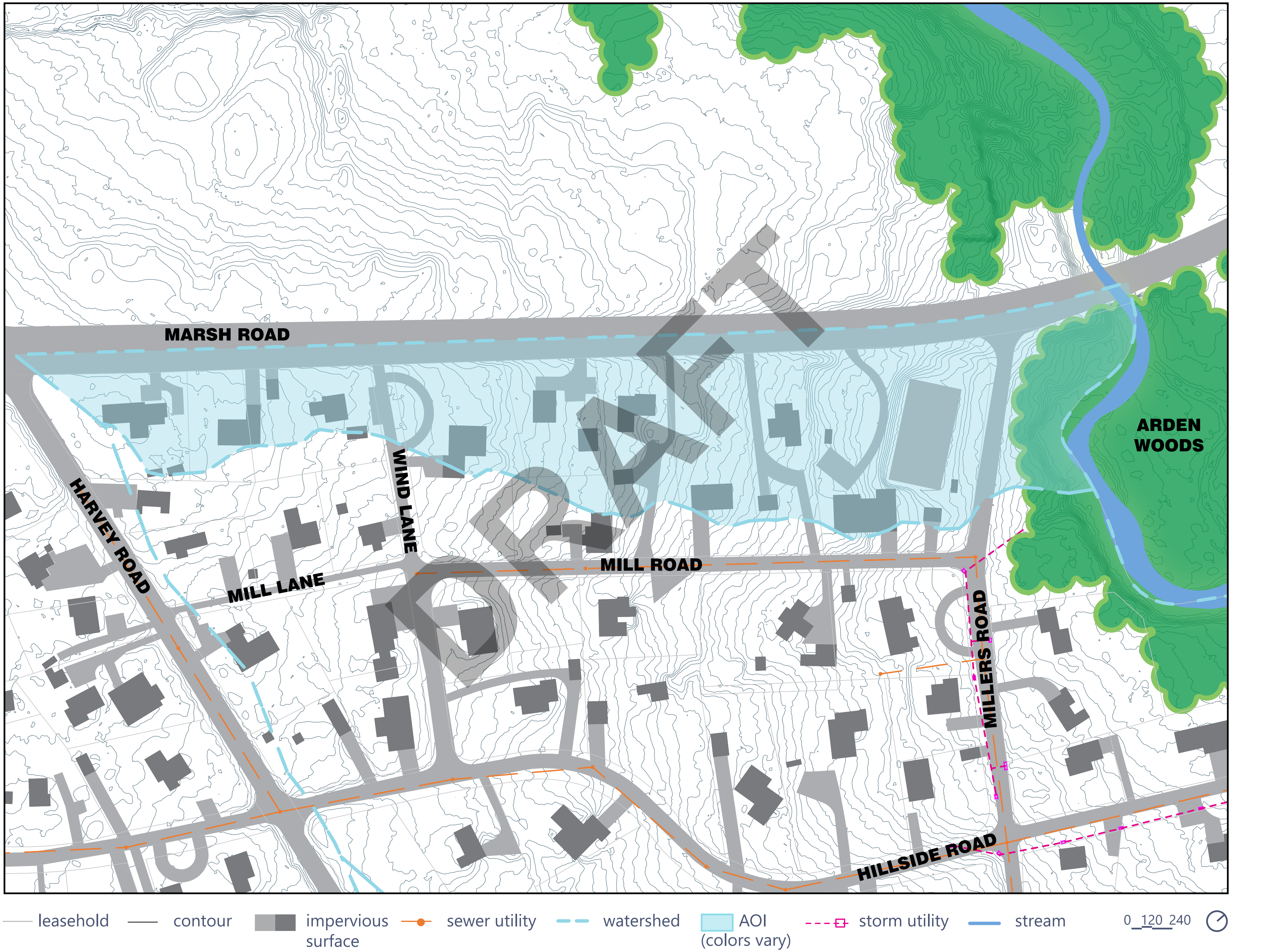
4.2.d WATERSHED D

The area for watershed D equates to approximately 5.5 acres. Approximately 35.9% of this watershed is covered by impervious surfaces. Several of the homes within Arden have double driveways connecting to both Mill Road and Marsh Road. This, and the additional shoulder along Marsh Road, is likely the reason why Watershed D has the highest percent of impervious coverage within its boundaries; however, impervious surfaces within the watershed show no signs of significant water quality impairments generated by poor drainage within its boundaries, there is some mild erosion in the woods.

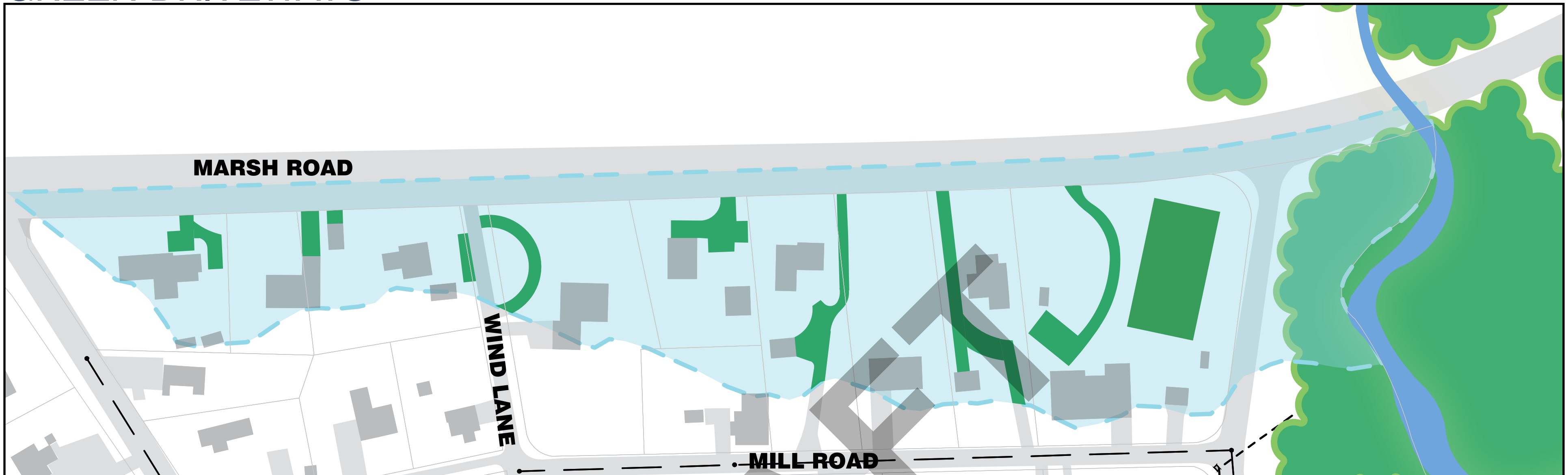
The watershed has a general flow from west to east, draining into the South Branch of Naamans Creek. Marsh Road has a crowned topography and runoff from the eastbound lanes joins this watershed. Although addressing the drainage along Marsh Road is outside the scope of this project, it does appear that the road runoff is limited to the portion of roadway directly abutting the watershed, as opposed to being piped in from an unknown or distant watershed boundary, such as is the case in Watershed A. Topography suggests runoff generated from Marsh Road takes a general “bleed” to the Creek, with some of the runoff heading down Millers Road before heading to the Creek and some of it making its way under the Marsh Road guardrail and through the woods to the Creek. The constriction of the stream course under the bridge may cause some erosion but no strong swales were observed in the contours generating from the bridge over the Creek.

Within the Arden boundary areas of stone are visible to each side of Millers Road in what appears to be the topographic low point. Along the wood side the stone is assumed to be placed for erosion mitigation, which appears a functioning methodology as no strong soil rills were observed. This area should be monitored to ensure stability remains. If the erosion gets worse, or roadway infrastructure appears compromised, converting the stone areas to a more formal stone infiltration facility or variation of, could be considered with likely minimal impact to the Woods. This plan does propose other opportunities, aside from a downstream BMP, to assist in mitigating water quality impairments.

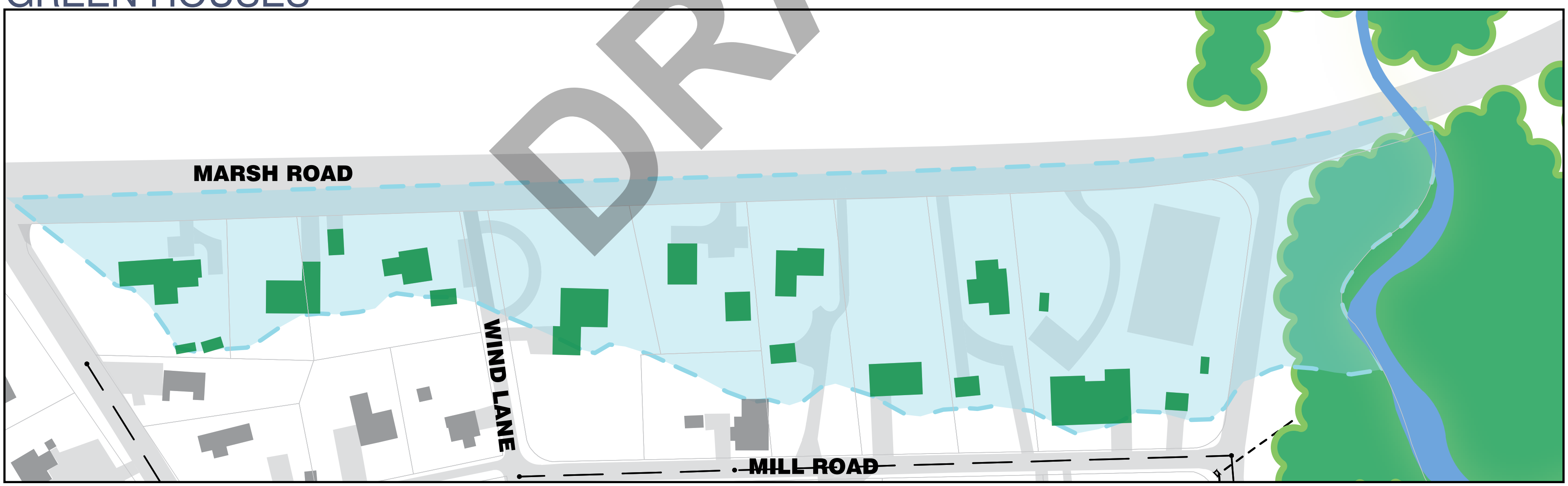
This watershed could be described as a textbook example of non-point source pollution, there is no defined point or pipe discharging pollutants from the watershed to the Creek. The watershed has no obvious signs of water quality impairments. It is at the top of the Arden watershed and it is within the top 4 of 10 watersheds in terms of highest percent impervious coverage. Of those watersheds, it is the smallest in size, if watershed J is considered part of watershed C as noted in the introduction. The large amount of impervious surfaces in the small watershed can have a disproportionately large effect downstream and have a significant pollutant load. Although opportunities to implement leaseholder initiatives is suggested throughout Arden, this is the primary approach recommended for this watershed; remove unnecessary impervious surfaces and add BMPs to reduce runoff from the existing impervious surfaces. The following pages illustrate the cumulative effect implementing porous paving and roof run-off capturing could have at reducing the effective impervious. It should be noted that rain barrels alone are unlikely to capture the full water quality event. This plan assumes the one tennis court within the watershed is composed of impervious materials and has been considered as driveway material in the following narrative.


MARSH ROAD
HARVEY ROAD
WIND LANE
MILL LANE
MILL ROAD
MILLERS ROAD
HILLSIDE ROAD
ARDEN WOODS
DRAFT
leasehold
contour
impervious surface
sewer utility
watershed
AOI (colors vary)
storm utility
stream
0 120 240

GREEN DRIVEWAYS



GREEN HOUSES



As mentioned above, the primary recommendation for this watershed is to consider removing all unnecessary impervious surfaces. Surfaces that must remain, and future plans for paving or buildings, should consider permeable and/or rain capture systems.

If all of the driveways and one tennis court within the watershed were changed to porous paving the amount of impervious surface would be reduced from 35.9% to 25.6% effective impervious. Estimated costs for the previous paving systems would be $1million*.

If all of the structures with roofs on them within the watershed implemented a catchment feature for all portions of the roof, such as a rain barrel or cistern, the amount of impervious surface would be reduced from 35.9% to 27.3% effective impervious. Estimated costs for the roof runoff capture systems would be approximately $25,000*. A do-it yourself type system for each structure is likely to be less than half of this cost.

If all of the structures with roofs on them within the watershed implemented a catchment feature for all portions of the roof, such as a rain barrel or cistern and all of the driveways and one tennis court within the watershed were changed to porous paving, the amount of impervious surface would be reduced from 35.9% to 17.6% effective impervious.

Note the estimated costs for this watershed have been edited: one, to better reflect the large scale cumulative nature of the installation and two, implementation of cisterns and rain barrels can vary widely in cost depending on installation techniques and no reliable source was able to be utilized.

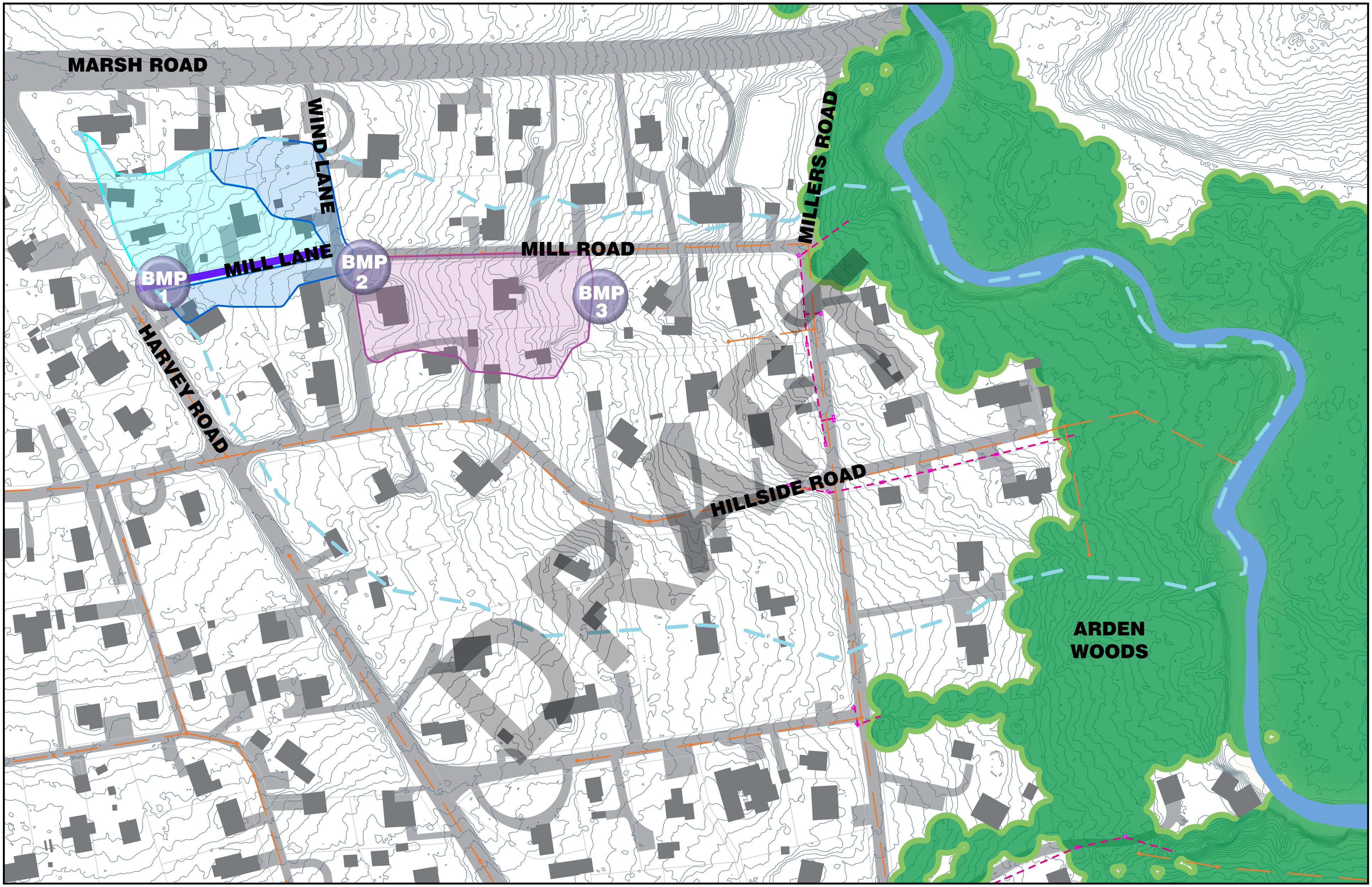
4.2.e WATERSHED E

The area for watershed E equates to approximately 19.5 acres. Approximately 19% of this watershed is covered by impervious surfaces. The surface runoff generally flows from west to east where it joins the South Branch of Naamans Creek. The watershed contains two primary Arden east/west roads, Mill Road and Hillside Road. The watershed has a mix of strengths and weaknesses regarding water quality impairments.

Beginning at the top of the watershed is Mill Lane, a small road with no through traffic and minimal utility conflicts. The road is asphalt paving and based on the contours and site observations, it is believed the upper parts of this watershed flow toward Mill Lane and then quickly run downstream to Mill Road. Once at the intersection, the stormwater runoff combines with that from Wind Lane and quickly travels down the steeper slopes of Mill Road. Runoff from and on Wind Lane, south of the intersection, flows to Hillside Road via a concrete gutter. Mill Road, south of the intersection with Wind Lane, appears to be crowed with a gutter along the western half and no or limited gutter for the eastern half; the north side appears to have a curb line along much of the road but in some areas it lacks definition, this appears likely due to age and vegetation growth. The landscape directly south of Mill Road appears to form broad shallow swales around a few homes and travels through leaseholder yards before making its way to Naamans Creek; in areas where the gutter is gone or limited, road run-off joins these swales. Larger storm events may cause overland flows to contact structures. The landscape north of Mill Road flows either directly to Millers Road or to Mill Road where it joins water flowing down the north side of the street and both drainage points enter a catch basin to an outfall in Arden Woods. The storm flows enter the woods in two locations, flow off the street at the opening in the fence where a trail starts, and the outfall area from the catch basin. The trail is slightly eroded. The pipes in the woods is an unclear arrangement of two pipes existing at one location to a concrete swale. The swale is falling apart and the channel eroded below it. The concrete should be removed and the area stabilized with low impact channel restoration, such as those noted for Watershed A. From the second highpoint in the watershed at the intersection of Harvey Road and Hillside Road, the storm runoff appears fairly stable as it moves down Hillside Road. The road has gutters along each side for the entire length from Harvey Road to Millers Road with catch basins at the bottom along Millers Road. While the curbing works well for drainage, it is not ideal for water quality as roadway pollutants travel directly to Arden Woods and what isn't absorbed by the riparian buffer, directly enters the Creek. The desktop analysis illustrated topography along the northern side of Hillside Road that suggested water was traveling through leaseholder lands but no clear outfall point to Millers Lane was visible during a site inspection. It is understood this drainage issue, that could have been contributing to water quality impairments, was alleviated through leaseholder initiatives.

To respond to water quality impairments within watershed E, this plan is suggesting three BMPs, each represented by a purple dot, as well as a leaseholder initiative. BMP E1 would be to implement porous paving for Mill Lane. The minimal vehicular use of the Lane and the opportunity to capture and slow down the run-off from higher up in the watershed, makes it a good candidate for such an intervention. This BMP is illustrated with a blue line over Mill Lane. An intervention in this area could treat some or most of the area highlighted in light blue, with an impervious area of approximately 0.2 acres, reducing the overall effective impervious cover to 18%.

The second recommended BMP is bio-retention garden E2 at the southwest corner of Wind Lane and Mill Road/Mill Lane. This corner is where stormwater appears to combine and gain momentum downhill along Mill Road. Reducing the intersection radii and implementing a BMP at this location would benefit drainage by slowing the stormwater flows higher up in the watershed and allow time for pollutants to settle out. An intervention in this area could treat portions of the area highlighted in deep blue, with an impervious area of approximately



leasehold contour impervious surface sewer utility watershed AOI (colors vary) storm utility stream 0 200 400

0.13 acres, reducing the overall effective impervious cover to 18.3%.

The third BMP is to implement bio-retention garden E3 on leaseholder land between 2204 and 2212 Mill Road. Prior to any BMP installation, it is suggested the gutter currently along the south side of the road be continued down to the bottom of Millers Road. Currently, the quick moving stormwater flowing down Mill Lane and Mill Road appear unmanaged in this area, implementing the upstream BMPs and gutter will likely assist in reducing the run-off to this area but based on the topography, stormwater runoff will continue to flow across the yards to Millers Road. The newly continued gutter is suggested to have a break or inlet in it to continue to allow some road run-off to the facility to reduce downstream pollutants and peak flows. The potential for this facility to safely overflow to a storm drain network does appear feasible given the proximity of the existing storm drain network along Millers Road. The BMP in this area could treat some or most of the area highlighted in purple, an impervious area of approximately 0.28 acres, reducing the overall effective impervious cover to 17.6%.

The last suggested intervention is to reduce sediment transport along Hillside Road and thereby reducing pollutant transport directly into the storm drain system at the bottom of the watershed. During a site visit stone from a driveway further up in the watershed was visible at the catch basin. If leaseholders with stone or compacted soil driveways implemented porous paving for their driveways, or at a minimum, the apron area at the intersection of the road and the driveway, this will help reduce sediment transport and aid in improving water quality. Given the lack of space in Arden maintained areas along Hillside Road, any leaseholder initiatives, such as rain gardens or cisterns would also be beneficial to the watershed.

Upon completion of drafting this plan but prior to final release, the authors were approached by a resident for suggestions to solve a drainage problem in their yards. Upon further discussions it was realized some of the drainage descriptions provided in this narrative did not provide a complete understanding of storm flows within this watershed. Although nothing discussed altered the water quality recommendations of this plan and the leaseholder concerns didn't appear to directly effect water quality, they still appeared relevant to include in this narrative. As noted above Hillside Road appears stable with gutters on both sides; the contours indicate some runoff does swale slightly north at the intersection with Millers Lane. The multiple catch basin system along Millers Road north of Hillside Road appears adequate from a desktop analysis. Discussions indicate it might be good for future studies to consider the capacity of this system. The site visit suggests water moves too fast during large storm events and/or the catch basins surcharge and water rapidly turns onto Millers Road and heads north. The rational why the catch basin system along Millers Road is not proving completely effective is unknown and outside the scope of this project; it is possible the stormwater is still moving too fast, the system is undersized, or other reason for the lack of capture. The lack of erosion at the outfall location for the Hillside Road storm drain network supports the potential that not as much water is being captured in the Hillside network as intended. The leaseholders concerns did appear evident that heavy flash storm events, which are likely to increase, do travel down their driveway and flood portions of their leasehold. Although driveway damage was visible it appears the structures are likely mitigating the flows from generating erosive forces through pervious areas and introducing sediment loading to the Creek. As a drainage issue this plan can't provide any recommendations but with a site visit appearing to suggest their problems are generated by a lack of problems along Hillside Road, it seemed an incomplete description of the watershed to not mention the discussion. This plan does recommend should Arden implement any future roadway or drainage improvements within this area, the modifications consider the problems relayed and seek to incorporate green infrastructure within any improvements. Perhaps the intersection could be modified such as is suggested at the intersection of Mill Road and Wind Lane or as suggested in Watershed A.

Intersection of Millers Road and Hillside Road; deposited stone visible around catch basins, likely washout from upstream stone driveways.

Leaseholder driveway; wet driveway markings and visible erosion suggest unmanaged storm runoff in this leasehold and the downslope leaseholder.

Intersection of Mill Road and Wind Lane; debris in valley gutter suggest mild low point; also visible in the background of this image is the steep gradient down Mill Road from this intersection.

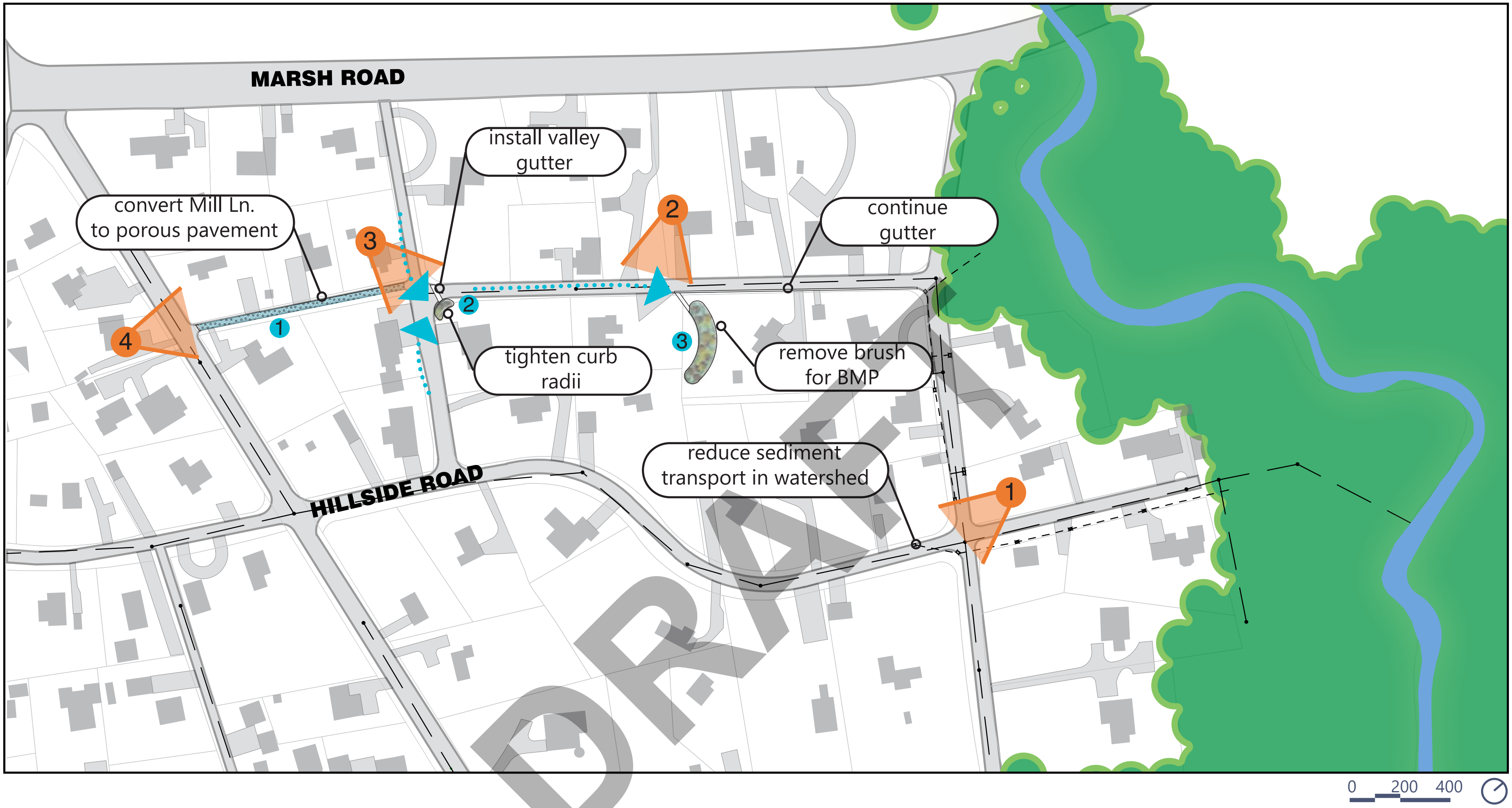
Mill Lane; image taken from Wind Lane intersection with Mill Lane in the far background; note the debris lines from stormwater runoff flowing through the area.

To assist in treating water quality and preventing sediment and pollutant transport downstream, it is suggested an area of porous paving be installed and two bio-retention gardens. With Mill Lane appearing to be a dead end vehicular street with only pedestrian movement through to Mill Road, transitioning it to porous paving appears to have minimal feasibility constraints. Utility conflicts and under-drain connections would need to be professionally designed. The area illustrated to be replaced with porous paving, E1, is approximately 3,000 sf. and includes both the paved surface and stone surface connection to Wind Lane. The drainage area for the porous paving is ~40,770 sf. The impervious area within this drainage area is ~8,700 sf. (21.4%). The footprint as described at 1ft deep would support a storage volume of ~1,200 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $73,800*.

The installation of bio-retention garden E2 at Mill Road and Wind Lane will be a tight fit, however the potential benefits make it worth including in this plan. A valley gutter or re-grading of the intersection would be required to capture the majority of Wind Lane north of the intersection and have it cross to the south side. As it appears now, Wind Lane drains northeast and then travels down the depressed stone curb to continue down the north side of Mill Road, which would bypass the garden without re-direction. The drainage area for this garden is ~28,885 sf. The impervious area within this drainage area is ~5,663 sf. (19.6%). A garden footprint as shown at 2ft deep would support a storage volume of ~215 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility installation would be $20,000*.

The installation of bio-retention garden E3 midway along Mill Road is proposed on leaseholder lands. This facility is suggested in an area that currently appears to be low quality scrub vegetation. The earthwork and clearing required to install this facility appear to be minimal but construction drawings should be prepared by a licensed professional to ensure safe conveyance away from any structures. As noted earlier, the gutter along Mill Road should be continued first, to reduce unmanaged flows into this area. A second swale or other connection to the roadway gutter can be installed such that the facility is able to capture and treat road runoff from the drainage area with a safe overlfow system to direct water away from structures. The drainage area for this garden is ~53,500 sf. The impervious area within this drainage area is ~12,200 sf. (22.8%). A garden footprint as shown at 3ft deep would support a storage volume of ~3,500 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $186,000*

As noted earlier, Hillside Road appears relatively stable but would benefit from leaseholders implementing BMPs to reduce driveway stone transport downstream during heavy rain events.


MARSH ROAD
HILLSIDE ROAD
install valley gutter
convert Mill Ln. to porous pavement
continue gutter
tighten curb radii
remove brush for BMP
reduce sediment transport in watershed
1
2
3
4
DRAFT
0
200
400

4.2.f WATERSHED F

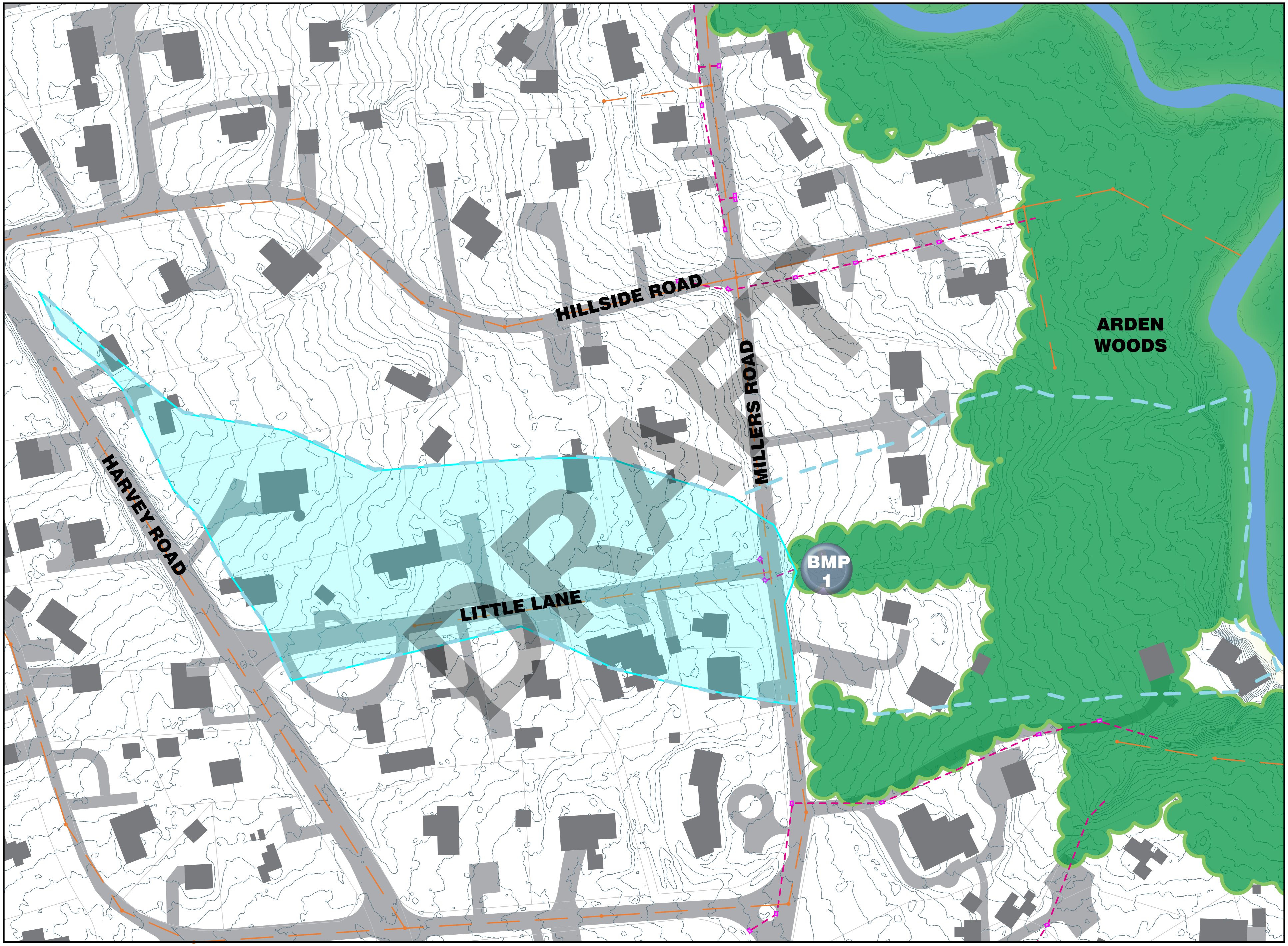
The area for watershed F equates to approximately 7.75 acres. Approximately 15.6% of this watershed is covered by impervious surfaces. The surface runoff generally flows from west to east where it joins the South Branch of Naamans Creek. The watershed contains nearly all of Little Lane, with a portion of Millers Road. The two high points in the topography define the boundary along Millers Road, making it a smaller portion of roadway water quality impairment contributions than Little Lane.

Starting at the top of the watershed the intersection at Harvey Road was reviewed for potential runoff interception. There is a small vegetative island at the intersection. The island and general intersection topography functions as a high point, not a low point, likely to prevent water from Harvey Road traveling down Little Lane; introducing a low point to receive run off for treatment is likely to be difficult and potentially have unintended consequences as rain events continue to be less predictable. The speed limits for traffic on Harvey Road were also reviewed and to maintain sight distances, modifications to add vegetation to this intersection are not suggested. A potential size was also evaluated and the intersection appears too narrow to provide a BMP with any measurable effect on water quality, this analysis combined with the other evaluations, prevented a recommendation from being provided in this area.

With no ideal locations at the top of the watershed, the areas along Little Lane were evaluated for improvements. Little Lane does not have any defined gutters or other drainage structures but the curb lines appear stable, and no visible signs of poor drainage patterns generating water quality impairments were observed during site visits. There were no areas within the Arden landscape along Little Lane that illustrated a cost effective BMP implementation. Given the lack of Arden maintained land (non-leaseholder) to implement BMPs, this plan suggests leaseholders implement leaseholder initiatives such as rain barrels, rain gardens, and other BMPs to reduce pavement and roof stormwater runoff.

The significant water quality impairment within watershed F stems from the classic “end of pipe” scenario. All of the runoff along Little Lane and its contributing drainage area appears to run down hill towards the boundary between the wooded and built landscape. At the end of Little Lane there is a concrete chute that shunts the water off into the woods, or the runoff enters two catch basins at the end of the road and is diverted into the woods via a pipe terminating under the chute. Just after the woods-line the water runs unmanaged down to Naamans Creek. The increased speed of the runoff during storm events has over time created a long incised channel down to the Creek, a channel that has contributed to the sediment loading within Naamans Creek.

The limitations of Arden common land within this watershed prohibit implementing larger runoff preventative methods upstream and the recommended treatment is to implement stream restoration practices to arrest the active erosion within the channel. The length of the channel is quite long, according to contours it appears to be a minimum of 350ft of stabilization required to respond to areas of active erosion. Stream restoration is an effective technique but can be a costly upfront investment. This plan suggests three opportunities: 1) clear the area directly adjacent to the pipe and chute and implement a BMP with an outfall sized to not introduce any further erosion of the channel downstream. 2) clear the entire length and install stream stabilization practices for safe conveyance from the pipe/chute outfalls to the Creek. 3) work with a professional design team to potentially develop one or more targeted practices that prevents further erosion but works within existing tree cover, perhaps it is some combination of both 1 and 2 or an entirely new practice. The uphill start of the eroded channel, for which the BMP F1 will be treating, is identified with a purple dot.



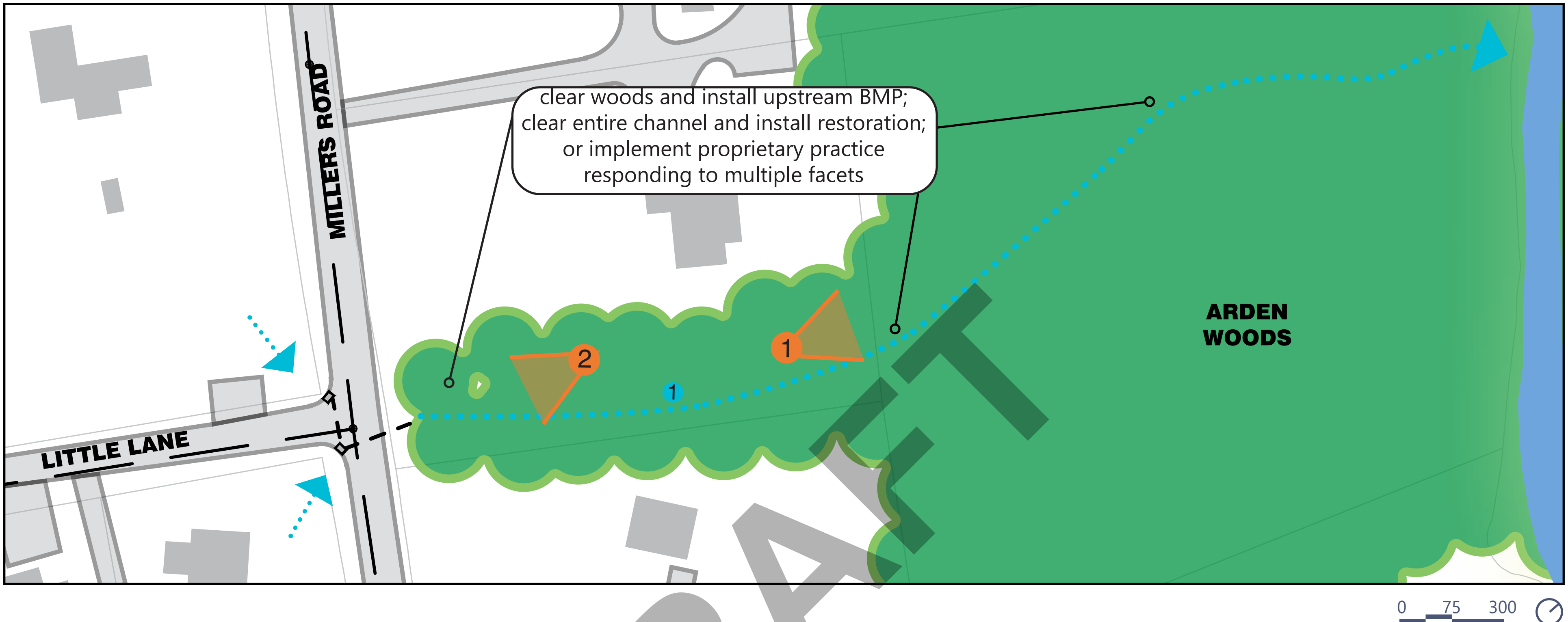
leasehold — contour — impervious surface — sewer utility — watershed — AOI (colors vary) — storm utility — stream — 0 150 300

1
Channel in woods opposite Little Lane, view downstream.

The eroded channel through the woods varies from 1' to 3' deep and is actively eroding carrying sediment to Naaman's creek and undermining woody vegetation to either side of it.

2
Channel in woods opposite Little Lane, view upstream .

At the top of the channel there are several large mature trees. For the time being this one is helping to slow the water by impeding its velocity downstream with its strong roots. Given the forecast of increasing storm events, this channel will likely continue to erode. Restoration measures can aid in preventing this tree's roots from becoming undercut which can have a negative impact on tree health and potentially destabilize the tree.



To assist in treating water quality and preventing sediment and pollutant transport downstream, it is suggested a BMP be designed for the outfall and/or the eroded woodland channel, by way of stream/channel restoration. Whatever BMP/restoration initiatives are taken, it is likely some amount of woodland clearing will be required, and likely on leaseholder land. This should be discussed by Arden and the leaseholder(s) prior to any design and implementation as leaseholder input could be a deciding factor in the best method of repair.

This plan recommends any practice in this area be looked at holistically and the best practice utilized that mitigates water quality impairments and balances other project facets such as cost, existing conditions, leaseholder preferences and any other project parameters that are not known from this desktop recommendation. For the purposes of comparison, this watershed is being evaluated by assuming stream channel restoration, F1, for a length of 350ft from the concrete chute along Millers Road to a point within the woods where the contours appear less channelized. The drainage area for this channel length is ~214,500 sf. The impervious area within this drainage area is ~58,300 sf. (27.2%). The current DE BMP manual estimates measured treatment of stream restoration on a case by case basis; the DE WQIP for the Christina River watershed estimates 100 linear feet of restoration is equivalent to 1 acre of treatment, which estimates an overall reduction of effective impervious within the watershed to exceed regulatory standards, producing a surplus of 2.16 acres of treated impervious. This 'over treatment' can be potentially be applied to another watershed lacking room for BMPs thus balancing out the overall treatment of the Arden's effective impervious. Estimated costs for the restoration installation would be $265,500*

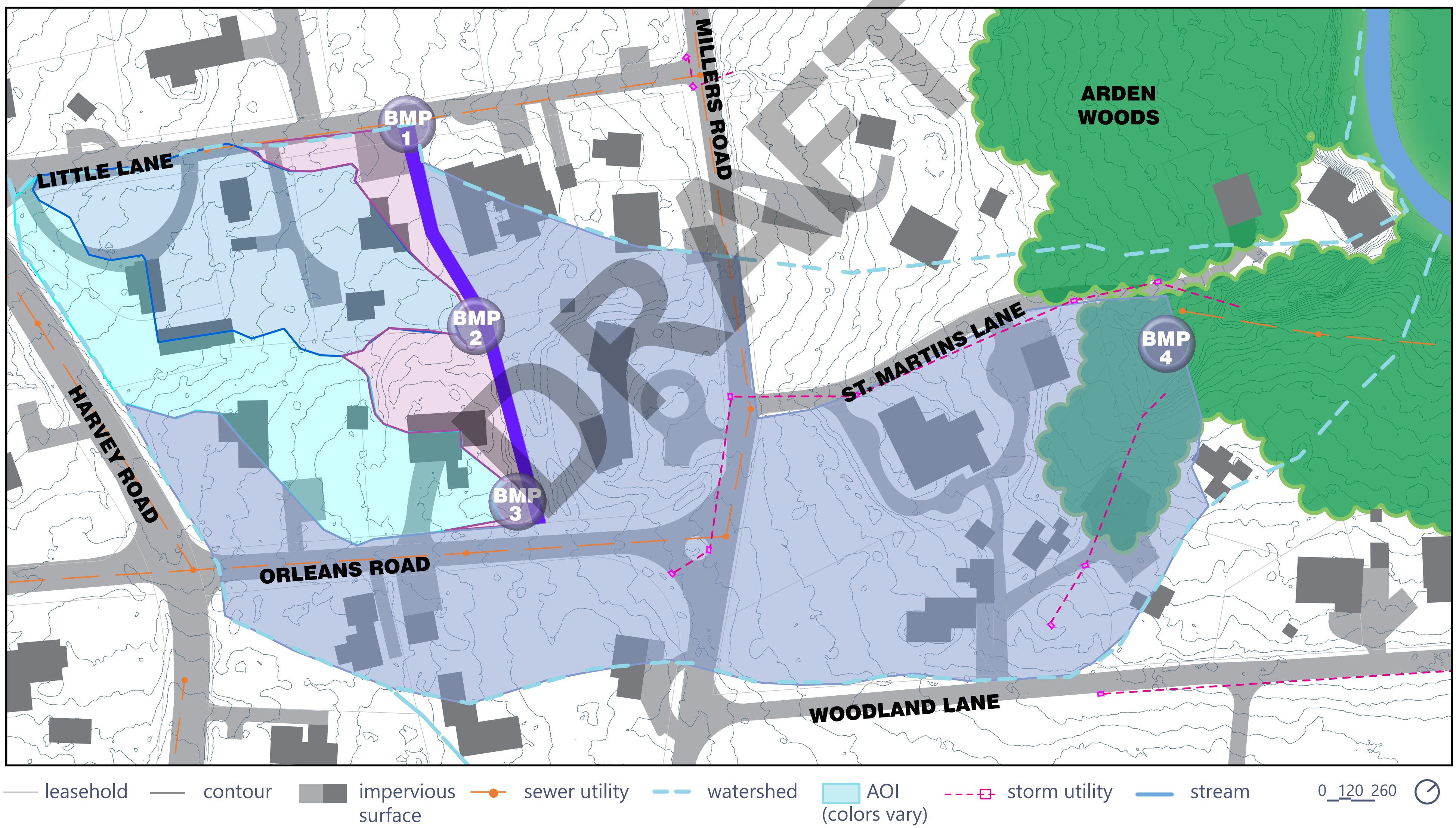
4.2.g WATERSHED G

The area for watershed G equates to approximately 8.5 acres. Approximately 23.2% of this watershed is covered by impervious surfaces. The surface runoff generally flows from west to east where it joins the South Branch of Naamans Creek. The primary roads within the watershed include Orleans Road east of the Harvey Road intersection, St. Martins Lane, and the portion of Millers Road that falls within the watershed. The watershed also contains Grocery Path, a foot trail between Little Lane and Orleans Road.

From the top of the watershed at Little Lane and Harvey Road, the surface water flows southeast towards Orleans Road. The Grocery Path creates a unique flow pattern in the watershed. Although storm water runoff still outfalls to the same location in the watershed, the Grocery Path appears to concentrate runoff toward the south side of the watershed and the southeast flow pattern and the backyard of 1900 Millers Road. During a site visit it was confirmed with this leaseholder that extensive drainage modifications have been made in the backyard landscape to divert storm flows away from the structure. This is visible in the contours with swales running north and south to the side yards of the residence and around to connect to Millers Road. Orleans Road appears crowned like the majority of roads within the Arden, with a low cobble curb along both sides. Drainage along the road appeared stable and the curbed storm flows joined those from the northern portion of the watershed to enter three catch basins along Millers Road. This catch basin network connects to a network of catch basins along St. Martins Lane. The St. Martins Lane catch basins appear to collect both road runoff and overland flow from the parcels directly south of St. Martin's Lane. These three areas that connect via drainage infrastructure, outfall into Arden Woods. Surface flow to the catch basins appeared stable. An additional drainage network that originates from the outdoor theater outfalls close to the St. Martins Lane drainage network and a swale has formed connecting it to the same outfall location where they combine and travel to Naamans Creek. The flow path to the creek appeared eroded.

To reduce downstream water quality impairments, principally road pollutants traveling through drainage infrastructure and sediment transport via eroding swales through Arden woods, this plan suggest implementing three BMPs higher up in the watershed along Grocery Path, and a restoration practice at the bottom of the watershed, each illustrated with a purple dot. The first intervention would be to replace the path itself with a porous material to aid in reducing storm events channelizing flow along the path. It is also suggested the new path installation be pitched uphill and a gutter installed on the west side. This strategy directs rain events away from the houses south of Grocery Path. Although the leaseholder at 1900 Millers Road indicated no drainage issues since their repairs, overall precipitation rates are anticipated to increase in the future. In addition to the purple dot, BMP G1 is illustrated by a blue line over Grocery Path. An intervention in this area could treat some or most of the area highlighted in pink/purple, with an impervious area of approximately 0.15 acres, reducing overall effective impervious cover to 21.5%. The two additional BMPs are suggested locations for bio-retention gardens. There are two areas that have naturally formed low points, likely due to Grocery Path. Converting the current collection points to bio-retention gardens will increase water quality treatment and slow down the rain events. Drainage infrastructure implemented within Grocery Path will allow overflow from the bio-retention gardens to be directed to Orleans Road where it is likely feasible to connect them to the existing storm drain network. The northern garden, G2, could treat some or most of the area highlighted in deep blue, with an impervious area of approximately 0.21 acres, reducing overall effective impervious cover to 20.7%. The southern garden, G3, could treat some or most of the area highlighted in light blue, with an impervious area of approximately 0.18 acres, reducing overall effective impervious cover to 21%. The fourth BMP, G4, suggests a restoration practice be introduced in the woods at the outfall of the theater drainage network, this will aid in stabilizing the outfall and reducing sediment transport to the stream, if a detention feature is integrated within the restoration practice this could also aid in slowing down the water prior to joining the Creek. An intervention in this location could treat some or most of the area highlighted in purple, with an impervious area of approximately 1.43 acres, reducing overall effective impervious cover to 6.4%. The implementation of G4 is anticipated to aid in reducing the erosion to the channel downstream. The channel should continue to be monitored and further analysis done should the implementation of G4 not reduce the erosive channel flows in that area. This plan also suggests properly maintaining the downstream catch basin along the St. Martins Lane network and keeping it free of woodland debris.

To improve water quality further, it would be advantageous to disconnect some portion of the Millers Road from the St. Martins Lane catch basin network. Potential options would include a surface BMP on either 1901 or 1905 Millers Road or a below ground BMP under the drive of 1900 Millers Road. Any of these options would create intensive modifications to the leaseholder land. If any leaseholders are willing, it would aid in reducing the quantity of water that is eroding the swale at the bottom of the drainage network.



1 The Grocery Path looking north toward Little Lane.

The path is extra impervious in the watershed that overtime could be changed to a material that supports water quality improvements within the Arden. Regardless of material changes, the availability of Arden maintained land will aid in creating conveyance connections from the proposed rain garden BMPs to the downstream drainage network during overflow events.

2 Outfall of the theater pipe into the woods. Photo taken from downstream. The dark void in the rip rap slope is the outfall.

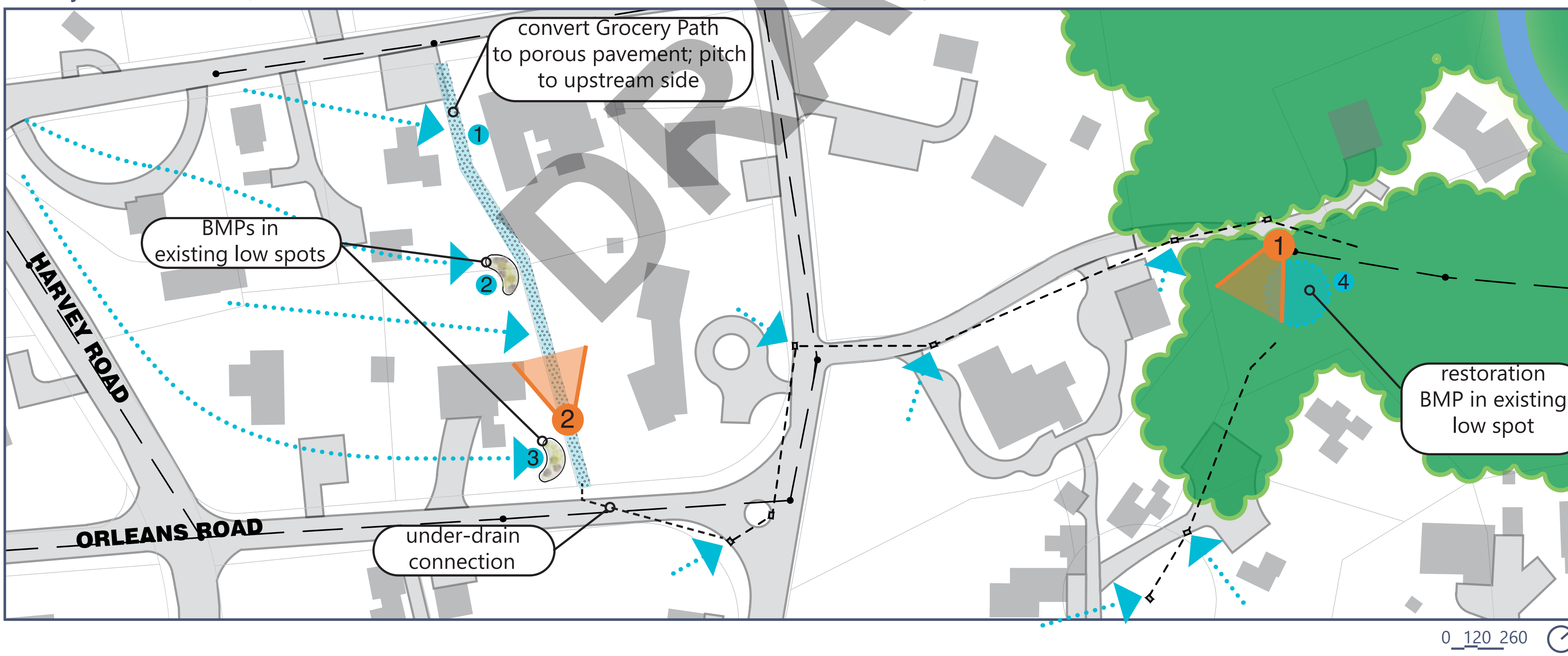
Visible in this image is the degraded area that would benefit to being modified to detain the outfall flows for a period of time to reduce erosion downstream. This reduction in storm flow sheer stress would likely increase the longevity of the sewer casing repairs as well as downstream channel restoration.

The transition of the existing asphalt Path to porous pavers or porous asphalt should be evaluated in regard to maintenance requirements Arden thinks would be feasible for them to undertake. The path is narrow with a limited footprint within common lands and access for equipment could be tight and should be considered in the evaluation. The area illustrated for G1, to be replaced with porous paving, is approximately 3,200 sf. The drainage area for the porous paving is ~19,300 sf. The impervious area within drainage area is ~6,350 sf. (32.9%). The footprint as described at 1ft deep would support a storage volume of ~1,250 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $76,900*.

The installation of bio-retention garden G2 midway along Grocery Path would be set in the existing low point near the bald cypress, care would need to be taken to integrate this facility around the existing tree roots; bald cypress is a water loving tree. The drainage area for this garden is ~38,750 sf. The impervious area within this drainage area is ~9,300 sf. (24%). A garden footprint as shown at 1.5 ft deep would support a storage volume of ~295 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $20,000*. The installation of bio-retention garden G3 on the southeast end of Grocery Path would be set in the existing low point. The drainage area for this garden is ~38,500 sf. The impervious area within this drainage area is ~8,000 sf. (20.1%). A garden footprint as shown at 1.5 ft deep would support a storage volume of ~295 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $20,000*.

These three interventions are best completed together. The gardens will require drainage elements to ensure safe overflow conveyance to an existing storm drain network. Given the minimal area of common lands it will likely be most feasible to install any drainage infrastructure adjacent to the Path. The two gardens and porous paving system would likely all connect to the same drainage network, thus making any installation in this area most cost effect to complete in conjunction with each other.

There is a small depression and minor erosion actively forming above the “dam” created by the sewer repairs toward the bottom of the watershed. The woodland restoration BMP G4 should be designed to mimic the current flow patterns but detain the stormwater longer and release it at a rate to reduce undermining the sewer infrastructure over time. The intervention within this location would benefit from a proprietary system that incorporates a detention facet while improving the woodland ecosystem; to provide a level of evaluation within this plan the system is being assumed as a standard detention facility. The area shown would create a detention area of ~2,500 sf.. With the existing erosion, clearing to access the BMP G4 would be minor comparable to other locations in the watershed, given its proximity to the roadway, leaseholder permission may be required if driveway access is required to support construction. The drainage area for this detention area is ~213,000 sf. The impervious area within this drainage area is ~62,300 sf. (29.2%). A detention facility at 3 ft deep would support a storage volume of ~4,200- cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $97,300*.



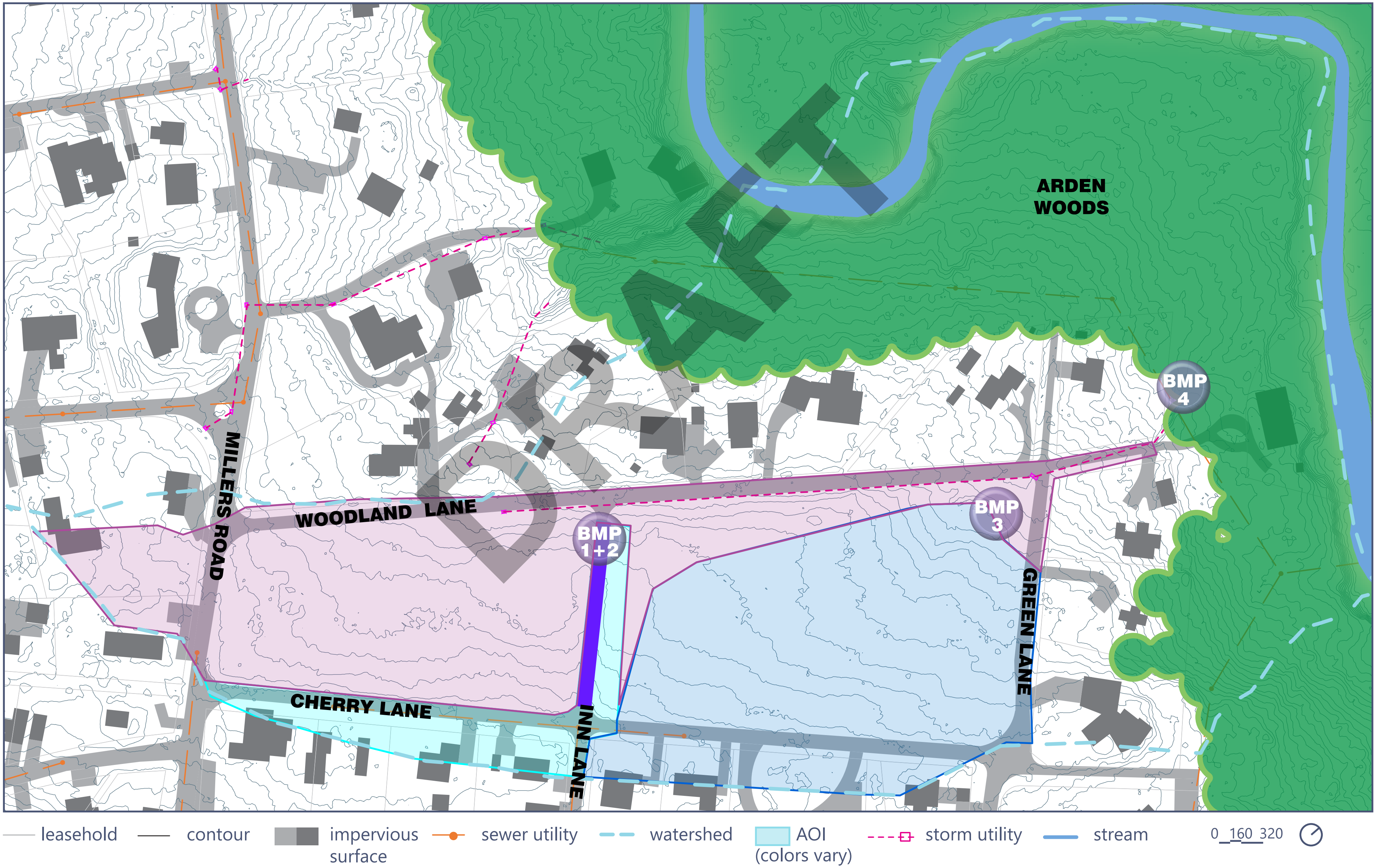
4.2.h WATERSHED H

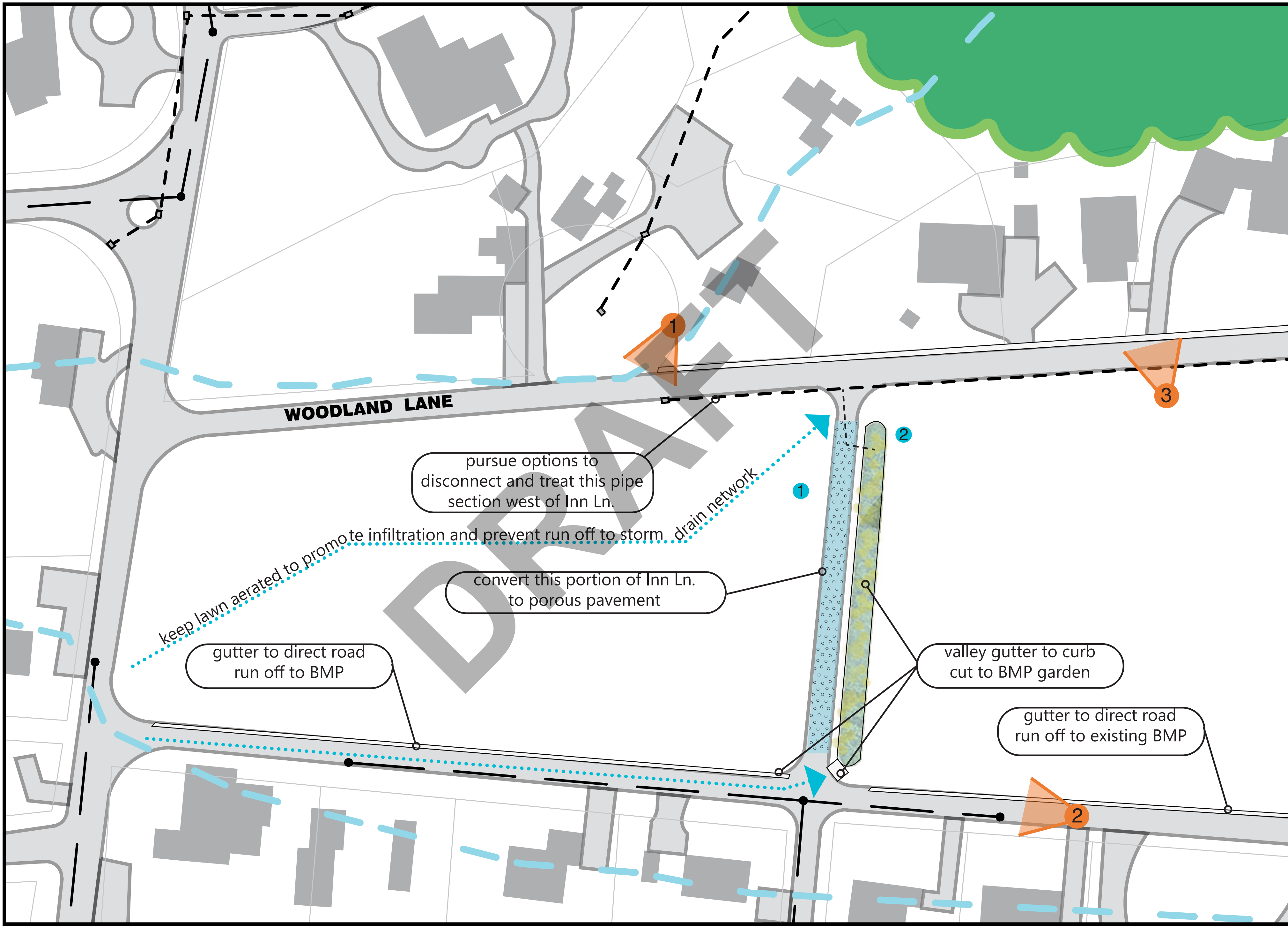
The area for watershed H equates to approximately 20 acres. Approximately 12% of this watershed is covered by impervious surfaces. The surface runoff generally flows from south to north where it joins a bend in the South Branch of Naamans Creek. The watershed is primarily defined by the large open park space that is bounded by Woodland Lane, Cherry Lane, Green Lane, and Millers Road, with Inn Lane traversing the middle. The majority of water quality impairments in the watershed comes from road runoff, as the watershed contains less residential housing than other watersheds within Arden.

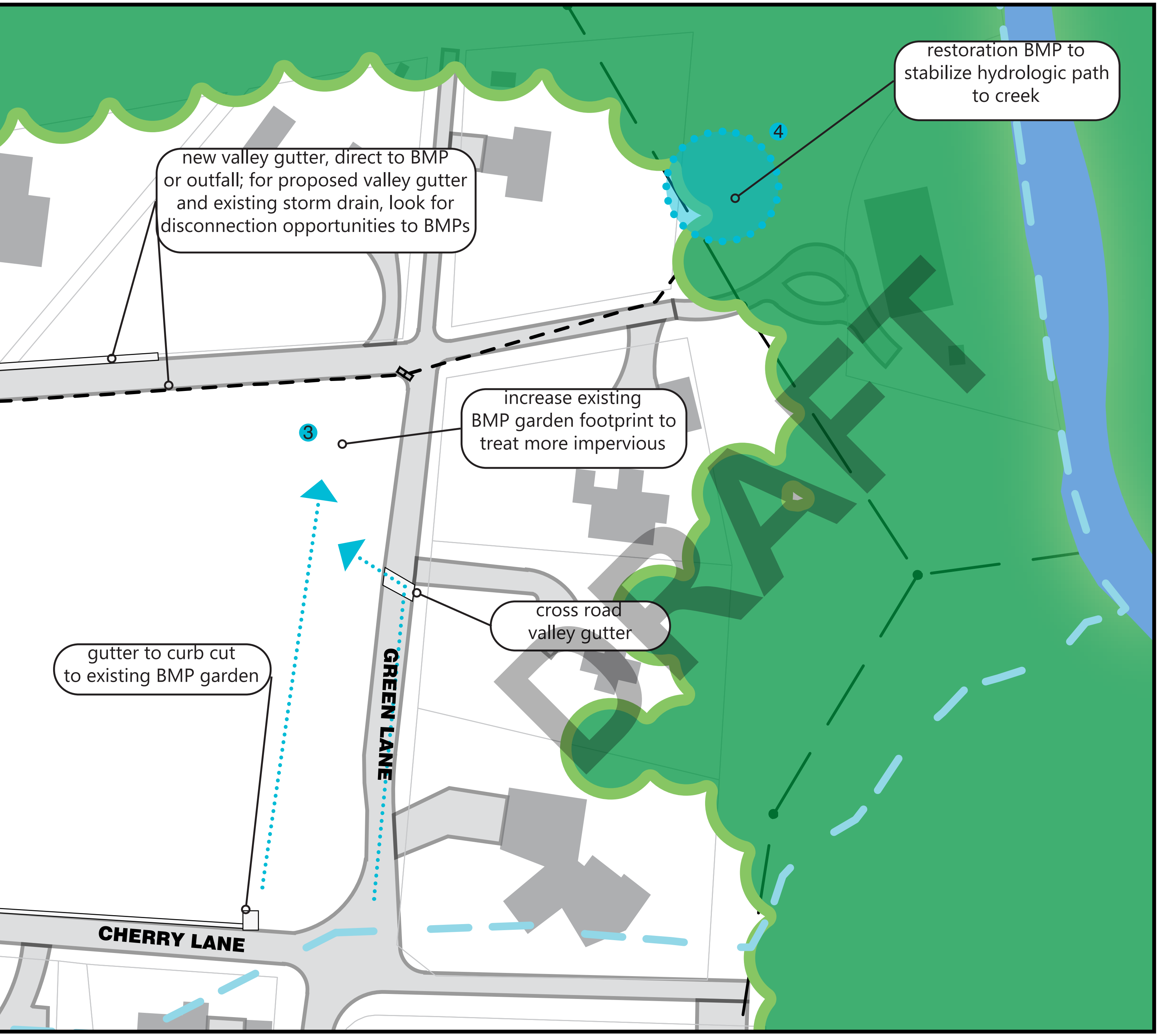
Woodland Lane is a long east west road through the lower portion of the watershed that carries most of the stormwater runoff generated by the built landscape within this watershed. From a highpoint just west of Millers Road, runoff travels east along Woodland Lane. The road cross section is flat to loosely crowned with variable curbing along the north side and a storm drain network on the south side. Storm runoff from the open lawn to the west of Inn Lane travels down to Woodland Lane. The runoff from the west half of Cherry Lane also makes its way to Woodland Lane via Inn Lane. From these three locations it appears stormwater either is caught by the storm drain network or travels unmanaged through the leaseholder properties to the north of Woodland Lane to join the Creek. The open space has a cobble curb surrounding most of it, thus the remaining east side of Cherry Lane joins runoff along Green Lane and travels north to join the storm drain network along Woodland Lane. The eastern lawn area of the park is captured by an existing rain garden in the northeast corner of the park. All runoff captured by the storm drain network outfalls into the woods. It is assumed the majority of runoff does get into the storm drain network, as the woods behind leaseholder lands north of Woodland Lane, where it is presumed runoff travels unmanaged through leaseholder land, does not indicate erosive swales in the contour patterns. On a site visit degradation was visible in an eroded channel forming from the outfall of the storm-drain network through the woods and to the Creek.

Recommendations for this watershed propose to disconnect the watershed impervious surfaces and increase opportunities for water quality mitigation prior to entering the storm drain network. The recommendations of this plan also seek to preserve open park space for recreational use. Inn Lane is suggested to be transitioned to porous paving which will function as water quality for road pollutants. Changing Inn Lane to porous paving is represented with a blue line, which could treat an impervious area of approximately 0.07 acres, reducing overall effective impervious cover to 11.6%. For the west half of Cherry Lane, it is suggested a valley gutter direct the run off past Inn Lane to be treated for water quality in bio-retention garden H2. This garden could treat some or most of the area highlighted in light blue, with an impervious area of approximately 0.33 acres, reducing overall effective impervious cover to 10.3%. Due to the proximity in location, for graphic quality, the porous paving of Inn Lane, H1, and the adjacent bio-retention garden are illustrated by one purple dot note BMP 1+2; it is possible that as the design evolves, these two systems provide additional capacity if they are connected. It is suggested the existing rain garden, H3, be re-designed as needed to provide additional capacity to capture the road run off from the east half of Cherry Lane and Green Lane. A gutter and/or swale would be required to get the road runoff to the garden to traverse Green Lane. Revising the existing garden could treat some or most of the area highlighted in deep blue, with an impervious area of approximately 0.39 acres, reducing overall effective impervious cover to 10%. The final treatment recommendation is to implement low impact channel restoration techniques, such as those discussed in Watershed A, and monitor the outfall area. At H4, an intervention in this location would respond to the water collected in the pink/purple shaded area, an area with an impervious coverage of approximately 0.62 acres, reducing overall effective impervious cover to 8.9%. Stabilizing any active erosion will aid in reducing sediments into Naamans Creek.

Although no visible water quality impairments were observed along the north side of Woodland Road, or any erosive swales identified by the topography, during a site visit, residents commented of experiencing erosion on their leasehold. This plan attributes this to the lack of consistent curbing, creating channelized areas during rain events. A valley gutter along the north side should assist in mitigated erosion through leaseholder land. Redesigning the drainage infrastructure falls outside the scope of this project, thus this plan does not propose any mitigation to the water collected on Woodland Road. Opportunities should be taken to disconnect and treat any valley gutter or storm drain generated flows prior to exiting the outfall and connecting to the Creek.




WOODLAND LANE
DRAFT
pursue options to disconnect and treat this pipe section west of Inn Ln.
keep lawn aerated to promote infiltration and prevent run off to storm drain network
convert this portion of Inn Ln. to porous pavement
valley gutter to curb cut to BMP garden
gutter to direct road run off to BMP
gutter to direct road run off to existing BMP
1
2
3
1
2



see additional narrative for call-outs on the following pages

0 80 160

1

Woodland Lane looking east.

The storm drain network on the south side of the road and the elevated curb in several locations along the north side direct untreated stormwater runoff to Naamans Creek. Opportunities to disconnect the flow paths and integrate water quality initiatives will help mitigate vehicular generated pollutant loading in the Creek.

2 Cherry Lane looking west.

The curbed open space prevents stormwater from flowing through open lawn and channelizes it to the downstream catch basins along Woodland Road.

3

Leaseholder image looking at driveway erosion along Woodland Lane.

Drainage initiatives help reduce erosion higher in the watershed however, water quality BMPs for the runoff, before or after drainage infrastructure, should be implemented where feasible.

The area illustrated along Inn Lane to implement porous paving for H1 is approximately 3,200 sf. The west end of Cherry Lane and its associated drainage area currently appear to run down Inn Lane, since this plan is suggesting a bio-retention garden to treat Cherry Lane, it is not included in the Inn Lane impervious area, thus the porous pavement would treat 100% of the drainage area impervious, as no other lands would drain to Inn Lane. The footprint as described at 1ft deep would support a storage volume of ~1,250 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $76,900*.

Porous paving is an effective water quality treatment option to replace existing impervious surfaces and reduce runoff, however studies have shown that BMPs that integrate plants are the most beneficial to treating for water quality and providing ecosystem services. The drainage area for the garden east of Inn lane is ~28,200 sf. The impervious area within this drainage area is ~14,500 sf. (51%). A garden footprint for H2 as shown at 1 ft deep would support a storage volume of ~3,800 cu. ft. This size would capture the water quality event of 2”. Typically bio-retention facilities are deeper than 1ft; the footprint is shown the entire length of Inn lane with the expectation it can be made deeper if the Woodland Lane drainage network is further evaluated and directed to this BMP; although outside the scope of this project, the location of the garden, near what is assumed to be the highest catch basin in this drainage area, makes it appear disconnection of the drainage network to treat road runoff for water quality impairments through this garden, is likely feasible. Estimated costs for the facility would be $202,000*.

The existing rain garden at the north west corner of the open space appears to be working well at catching runoff prior to entering the storm drain network, however topography suggests the existing drainage area to be composed primarily of lawn. This plan suggests modifying the roadways with curb cuts and valley gutters to introduce more road runoff to be treated for water quality impairments through this area before reaching the drainage network. A hydrologic analysis of the existing garden is outside the scope of this project however, it appears practical to direct impervious surface runoff to this area. The drainage area for garden H3 to capture portions of Cherry Lane and Green Lane is ~128,300 sf. The impervious area within this drainage area is ~17,100 sf. (13.3%). A garden footprint assumed similar to existing at 2ft deep would support a storage volume of ~1,550 cu. ft. This size would capture the water quality event of 2”. Estimated costs for the facility would be $82,200*. To be conservative in the evaluation, this estimate is based on costs to construct a new garden. It is suggested prior to implementing any retrofits for this garden and the Woodland Lane drainage network be evaluated for opportunities to disconnect some or all of the catchment system and treat the road runoff for water quality impairments through this garden.

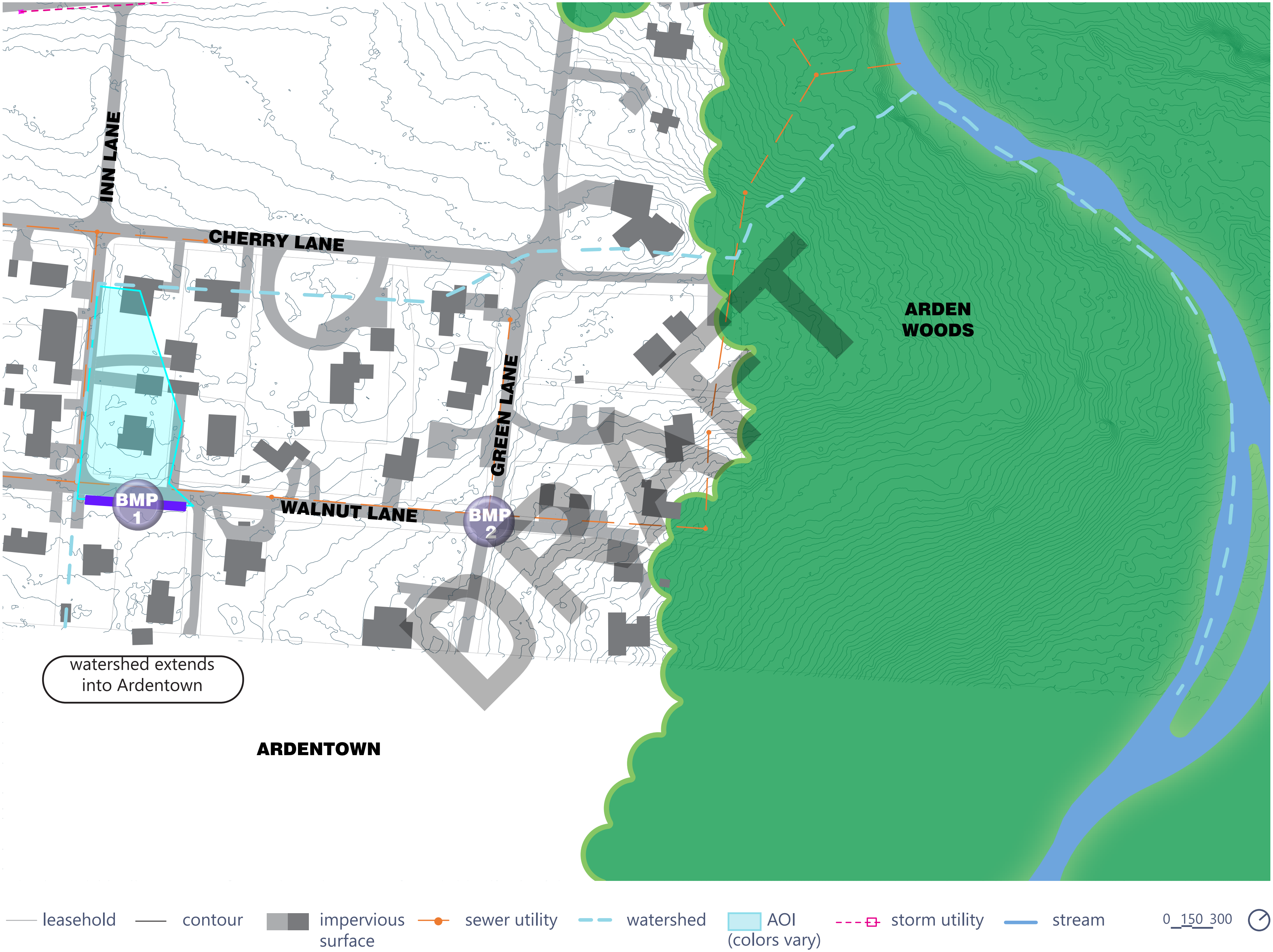
The outfall location of the Woodland Lane drainage network into the woods appeared to be moderately stable. It is evident at one point there was significant erosion through this channel. It is suggested the channel for H4 be monitored for degradation and stream restoration techniques implemented if continued sediment loss is observed. It is likely as upstream initiatives are implemented, the stress in this channel will be reduced and the side slopes further stabilize without direct restoration initiatives. If upstream improvements are implemented and minimal erosion is observed after a minimum one year monitoring period, this plan recommends utilizing volunteer labor to implement traditional low-impact stream restoration practices. The appendix section contains resources for stream restoration practices, low-impact describes those that utilize vegetation and only rock that is feasible to be carried by the average person, such as a bucket of small rip rap. Structural stream restoration techniques should be utilized if channel erosion increases and/or opportunities to disconnect the storm drain network and reduce the quantity of water exiting the outfall is not feasible, design for these interventions should be completed with by a design professional.

4.2.i WATERSHED I

The area for watershed I equates to approximately 15.5 acres within the Arden boundary. Approximately 12.4% of this watershed is covered by impervious surfaces. The surface runoff generally flows from north to south with some areas draining east. This watershed boundary extends into Ardentown however the watershed area reviewed has been modified to the Arden limits established by this study. If lands of Ardentown were included in the plan, the illustrated boundary would be a closed polygon, not just three sides as shown.

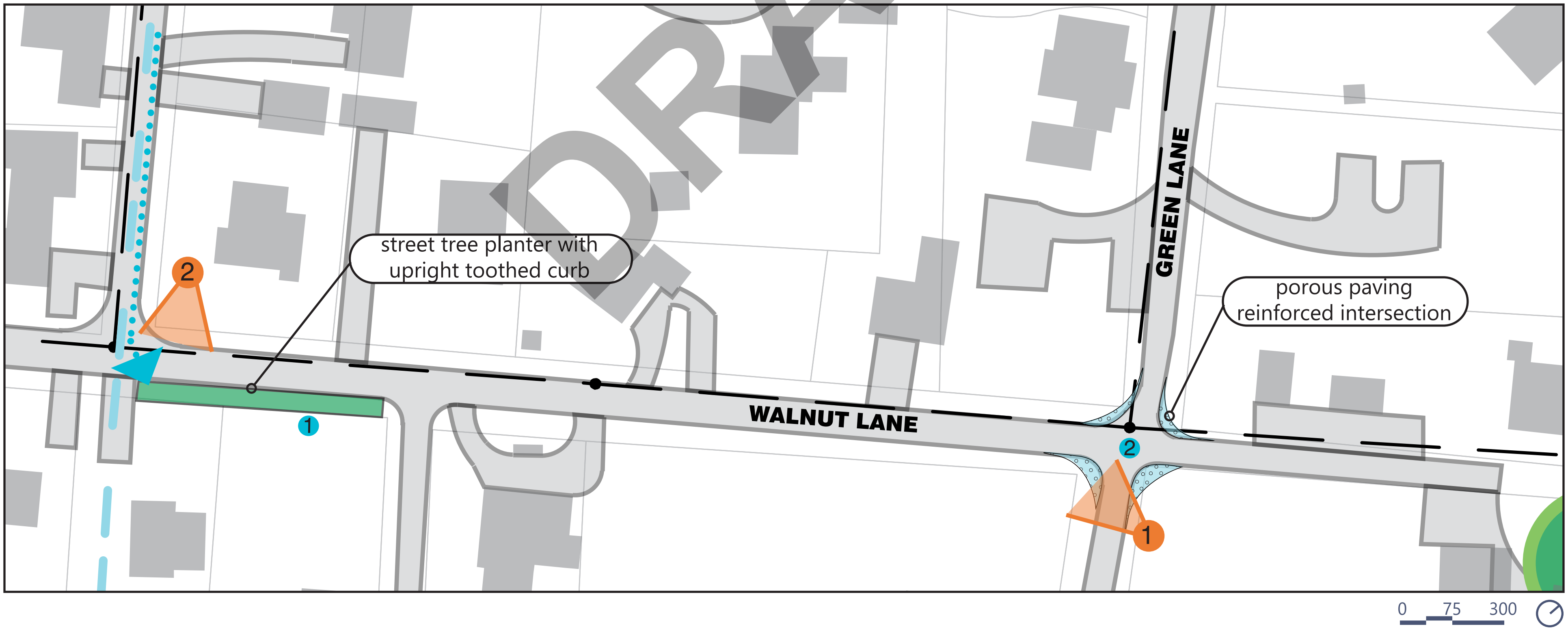
Two opportunities for water quality improvements were observed within the watershed and illustrated with a purple dot. Inn Lane is crowned and the western half is caught by gutters along Walnut Lane and directed to Watershed J; the eastern half does not appear to change direction at Walnut Lane and continues south into leaseholder lands. To treat the Inn Lane road runoff in this watershed, stormwater planter I1 could be implemented in the narrow lawn area in front of 2314 Walnut Lane. The planter would need to have a toothed upright curb to allow stormwater in but prevent vehicles from driving off the road. A review of the downstream drainage connections in Ardentown is recommended prior to undertaking design to fully vet the feasibility and potential cost of this BMP. Before implementing the BMP, a safe overflow path should be identified so no downstream residence in Ardentown is negatively impacted. Planter I1 in this area could treat all or most of the drainage area illustrated in light blue with an impervious area of approximately 0.24 acres, reducing overall effective impervious cover to 10.9%. The drainage area for the planter is ~25,700 sf. The impervious area within this drainage area is ~10,300 sf. (40%). A planter footprint as illustrated at 1.5 ft deep would support a storage volume of ~1,050 cu. ft. This size would capture the water quality event of 2". Estimated costs for the facility would be $55,900*.

The second opportunity illustrated in this watershed, I2, could also be implemented in several areas throughout Arden. During site visits vehicle tracks indicated vehicles cutting corners and ruts with tracked sediment observed on roadways. This is a common water quality impairment in many areas and is just one of the many pollutants present on roadways that are transported to our streams via stormwater runoff. Installing any hardscape material to form an apron behind the curb and/or edge of pavement would reduce the sediment dispersal, this plan recommends using a porous material to still allow for potential infiltration. Porous asphalt is generally more cost effective than porous paving, particularly for large areas such roadways. The small footprint of these intersection reinforcement areas may benefit from an interlocking paver producing more stability overtime with tire wear and having a dissimilar material marking the roadway versus the apron area. An intersection as illustrated, reinforced at all four corners is estimated to be $10,600 at approximately $17.75 per square foot.


INN LANE
CHERRY LANE
GREEN LANE
WALNUT LANE
ARDEN WOODS
BMP 1
BMP 2
watershed extends into Ardentown
ARDENTOWN
DRAFT
leasehold
contour
impervious surface
sewer utility
watershed
AOI (colors vary)
storm utility
stream
0 150 300

1 Image looking south where valley gutter ends and planter could be implemented.

2 Image of intersection with vehicle generated tire ruts.



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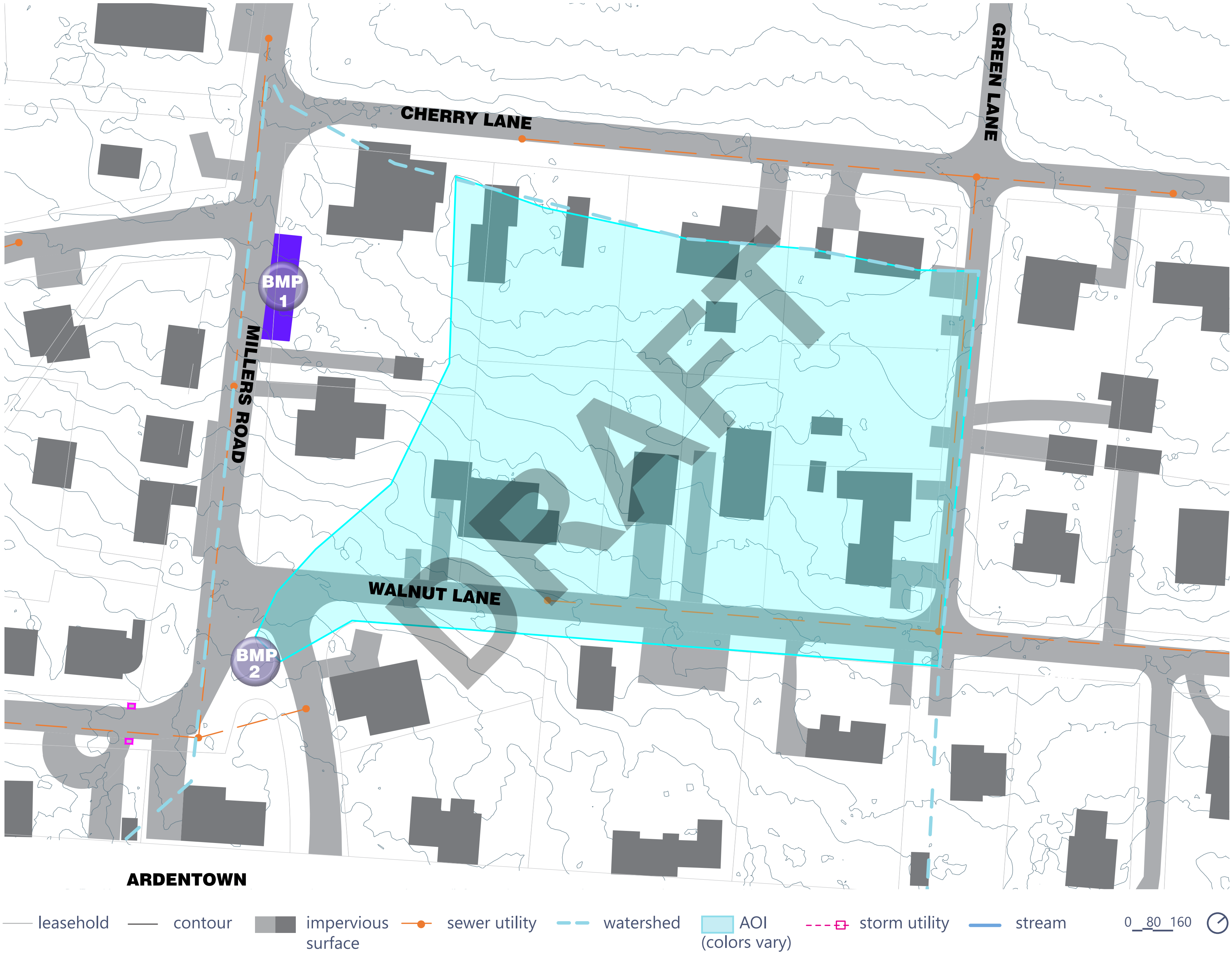
4.2.j WATERSHED J

The area for watershed J equates to approximately 4.75 acres with the Arden boundary. Approximately 31.3% of this watershed is covered by impervious surfaces. The storm flows through this watershed generally travel in a southern direction. Similar to watershed I, this boundary should be viewed as having been modified for two reasons. One, this watershed continues south into Ardentown which lies outside the scope of this project; two, the majority of the stormwater is directed, via roadways, to Lower Lane where it connects to the storm drain system of Watershed C. As discussed in Watershed C, the catch basin system along this road appears to connect to the Harvey Road system which appears to be overburdened during large storm events. BMPs implemented in this watershed would aid in reducing demand on the downstream drainage network.

Two BMPs are suggested for this watershed and represented by purple dots. Changing the public parking lot of the Craft Shop to a porous material would aid in reducing pollutant transport from the lot. Unfortunately the lot appears to be at a high point to the surrounding areas such that its unable to treat surrounding areas. By lowering the lot slightly some additional pollutant capture of portions of Millers Road may be possible but further investigations would be required to determine the extent of regrading needed. Without additional regrading, transitioning the J1 lot to porous paving is likely to treat the parking spaces, an impervious area of approximately 0.03 acres, reducing overall effective impervious cover to 30.6%. With no additional drainage area, the porous paving would treat 100% of the impervious area 1,350 sf.. The existing lot footprint with 1' of stone below it would support a storage volume of ~540 cu. ft. This size would capture the water quality event of 2". Estimated costs for the facility would be $33,225*.

The second proposed BMP would likely provide a larger extent of water quality treatment within the watershed. Currently the western half of Walnut Lane, west of the Inn Lane intersection, has gutters installed on both sides. The north side gutter directs water through the intersection with Millers Road via a valley gutter and connects to the catch basins on Lower Lane. The south side gutter has a similar flow path but to get to Lower Lane the valley gutter was extended through a landscape island at the intersection. It is suggested within the limits of the landscape island a bio-retention garden be implemented to treat the run off for water quality impairments. Garden J2 in this area could treat all or most of the drainage area illustrated in light blue with an impervious area of approximately 0.75 acres, reducing overall effective impervious cover to 15.6%. The drainage area for the planter is ~103,300 sf. The impervious area within this drainage area is ~32,500 sf. (31.5%). A garden footprint as illustrated at 2 ft deep would support a storage volume of ~1,050 cu. ft. This size would not capture the water quality event of 2", it falls short by a approximately 48.5% capacity; further design strategies should look to increase the footprint, potentially onto leaseholder lands and/or design a street planter feature to increase the depth of storage. Estimated costs for the facility would be $55,800*.

An option within this watershed that was not detailed further is the potential to install an underground storage system in the area of the parking bump out at the intersection of Millers Road and Walnut Lane, such that a catch basin might be installed at the end of the valley gutter coming from the north side of Walnut Lane. Underground storage has minimal effect on water quality directly. As discussed in the introduction, managing drainage can lead to indirect water quality benefits. This is particularly relevant in this location with the downstream watershed being the bottom of Harvey Road, as discussed in Watershed C. If further investigations make a BMP in area 9 of Watershed C impractical, this location may be beneficial in capturing larger storm events upstream to reduce the pressure on the downstream drainage network.



CHERRY LANE
GREEN LANE
MILLERS ROAD
WALNUT LANE
BMP 1
BMP 2
DRAFT
ARDENTOWN
leasehold
contour
impervious surface
sewer utility
watershed
AOI (colors vary)
storm utility
stream
0 80 160

1

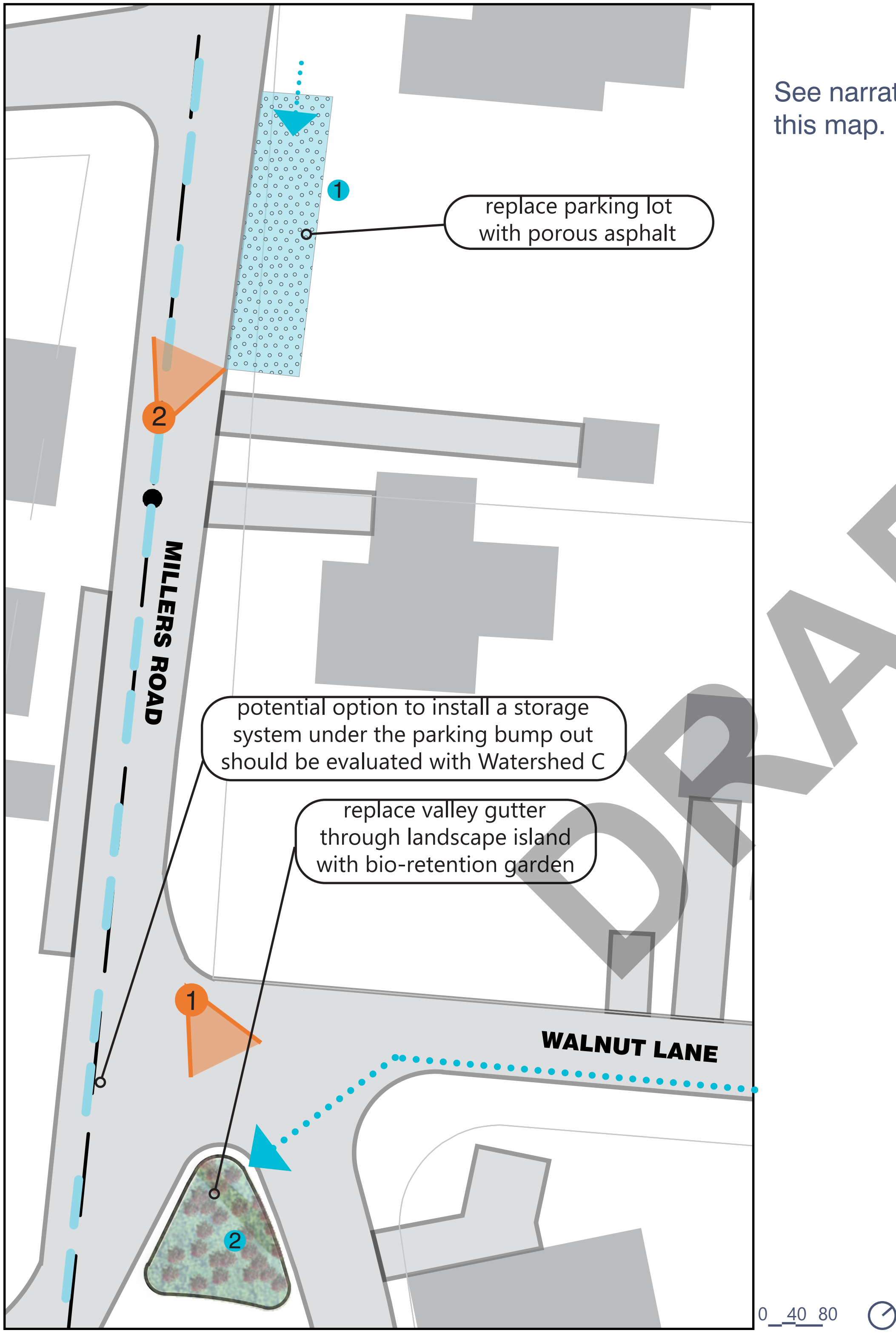
Millers Road Walnut Lane intersection looking south

The existing concrete valley gutter drains water to the catch basin system along Lower Lane by traversing through the landscape island.

2

Craft Shop parking lot, image looking north.

Opportunities to transition public lots to porous materials will increase water quality treatment in Arden.



See narrative on the preceding pages for design information noted on this map.

5 CONCLUSIONS & RECOMMENDATIONS

5.1 CONCLUSIONS

Guiding principles concluded by the Master Plan:

1. Impervious surfaces can be problematic within the landscape.
2. Capacity and resistance to clogging are important for surface drainage features.
3. The greater the amount of runoff, the greater the likelihood of negative impacts on the ecology downstream.
4. Stormwater can be managed through a variety of best management practices (BMPs).

Impervious surfaces rapidly translate rainfall into runoff taking pollutants on those surfaces with them as it travels toward Naamans Creek or Perkins Run. As the percent impervious cover increases, the amount of runoff, speed of runoff, temperature, and quantity of pollutants rises dramatically. Flooding is often the most dramatic experience people witness in watersheds with impervious cover. Reducing impervious cover reduces the magnitude of flooding in a watershed. While flooding may be a dramatic manifestation of higher percentages of impervious cover, runoff from impervious surfaces presents many less obvious hazards to the world around us. Untreated runoff carries hydrocarbons, excess nutrients, unhealthy bacteria, and sediments into our streams. These constituents damage and interrupt healthy ecological process and harm wildlife. Erosion damages aquatic habitat as well as human infrastructure.

Good drainage and effective stormwater management at times are at odds with one another. Removing water quickly from the surface of certain types of infrastructure can provide safe conditions for humans and add to the longevity of the built environment. Slowing down drainage can help sediments settle out of runoff and give more time for natural systems to capture, break down, and digest pollutants. The balance between these two is not binary or black and white, it is a spectrum. Plan for good drainage where required, for example, removing water from the immediate area surrounding a home's foundation is important, but in areas where poor drainage isn't a high risk, such as temporary shallow ponding in a park or yard, ponding or slow drainage may be acceptable and aids in reducing negative impacts downstream.

One important relationship is, typically the better the drainage, the more pollutants and energy are transferred to the natural landscape at the point of outfall. The greater the amount of runoff from impervious surfaces to an outfall location, the greater the size of infrastructure is required to handle the large storm events, as well as the greater the required investment in helping our natural systems accommodate this runoff. Reducing runoff can reduce long term investments in man-made infrastructure and facilitate the restoration of natural systems that promote clean surface waters. Energy can be a helpful way of looking at runoff. Water is heavy, about 8.3 pounds per gallon. Assuming a rainfall depth of 2", a storm that DNREC uses as happening twice each year, we can consider a simplified view of the energy it places on the landscape in terms of weight of water. Two inches of runoff over a typical parking space, 9' wide by 18' long, is about 202 gallons of water or 1,677 pounds of water. Extrapolate that area of impervious cover over a leasehold and consider how many 9' x 18' areas of impervious cover are on the leasehold? If you have a 1,000 sf home, a sidewalk, and a two car driveway, a modest home site, you could easily have 8 parking spaces worth of runoff or 13,416 lbs of water with 2” of runoff from the impervious surfaces on this single leasehold. This doesn’t include the lesser runoff that would occur from pervious surfaces such as lawn or landscape beds. Imagine this runoff over the entire watershed and you begin to see the extreme forces water exerts in pipes, swales, and streams. Since our heavy thunderstorms or tropical systems are capable of dropping many inches of rain, heavier storms dramatically increase the energy runoff introduced to our infrastructure and natural landscapes from impervious coverage. Reduce the runoff and you reduce the energy in the system.

Impervious cover is an integral part of the built environment and required to various degrees to utilize manmade infrastructure, with many locations requiring good drainage for safety. While we know less impervious cover is better, it is a condition that is unavoidable for certain uses. Best management practices ranging from rainwater capture and reuse, to planted depressions that permit a designed ecosystem to clean and slow stormwater runoff, provide a tool kit we can utilize to reduce the negative impacts of impervious cover on our health, safety, investment, and ecosystems. This document brings example BMPs to Arden for discussion and consideration. Some BMPs are easy and straight forward, others require additional infrastructure and are complex. Each watershed is different and the solutions as well as the complexity will vary by watershed. In general, the higher up in a watershed Arden invests in managing stormwater, the smaller, less expensive, and easier to maintain the BMP will be. It took a long time and a great deal of investment to arrive at the current conditions; it will take time and investment to improve the current unmanaged stormwater patterns. Stormwater runoff is forecasted to increase in intensity with climate change such that it becomes more important to thoughtfully manage it for not only today’s quality of life, but life decades from now.

5.2 RECOMMENDATIONS

This Master Plan recommends:

1. Implement BMPs to address impervious surfaces.
2. Take efforts to reduce the addition of impervious surfaces.
3. Stabilize outfalls using nature-based techniques.
4. Improve the ability of existing drainage systems to capture runoff.

The watershed analysis provides a planning level comparison of impervious cover, ranging from a low of 5.8% in drainage area B to a high of 35.9% in area D. As narrated above, the higher the percent impervious cover, the greater the contribution of stormwater runoff for a given area. A summary table of watersheds and BMPs is provided. In addition to capture and management abilities, each BMP has a cost associated to it, some are more expensive than others. The BMP selection process is more complex than targeting the highest percent impervious cover or lowest cost. We have ranked the BMPs according to a matrix to aid with the selection and phasing, in order to help the community focus investments in stormwater management. A score of 1 to 3 was applied to each criterion with 1 being less desirable and 3 being more desirable for a given characteristic.

The matrix scores BMPs based on the following five criteria:

1. Common Land: It is assumed implementing best management practices on common land would entail less coordination than one on leaseholder land. A high score equates to being on common land.

2. Meets WQ: The goal for a given BMP is to at least treat the regulatory runoff from a water quality (WQ) storm event. This is generally targeted as the minimum threshold for providing effective pollutant removal. A high score equates to treating the WQ event.

3. Meets 2YR or <: A facility that treats more than the WQ event such as a 2-year storm or greater provides more significant reduction in runoff than one that only treats the WQ event. This characteristic would more significantly reduce demands on downstream infrastructure compared to one that solely meets the WQ event. Due to available area, some BMPs could not be made larger. A high score equates to treating more than the WQ event.

4. Implementation Complexity: A rating of the overall complexity and constructability of the system. Complexity can not only relate to construction costs but also impacts design costs, utility relocation, and infrastructure required to direct the water to the facility. This criterion was determined based on the authors' experience and additional notes provided. A high score is a less complex system, a low score is a more complex system.

5. Cost By Treatment: This is a general comparison of the costs between BMP types. Surface BMPs such as detention or swales are less expensive than bioretention systems with engineered soils, which in turn are less than pervious pavement systems. A high score is less expensive per area treated, a low score is more expensive per area treated.

Two additional columns are offered for consideration, cost, and effective impervious reduction. As stated earlier in the document, the costs are planning level estimates for construction of the facility. They do not include design, permitting, or infrastructure that may be required in addition to the facility. A comment column is added to provide a generalized description of the complexities of the BMP. Total project costs can range from 1.5 to 3 times the stated construction costs. Effective Impervious Reduction characterizes the relative impact on the upstream watershed. The greater the percent reduction, the more effective the BMP.

The scoring is intended to aid in deciding which BMPs or groups of BMPs should be considered in more depth and to suggest phasing. Facilities with the higher sum (total score) are recommended to be considered before those with a lower sum. This Plan recommends the scoring criteria be guidance for additional expenditures of Arden's time and budget, as the community works toward managing its stormwater runoff. Once a facility or group of facilities is selected for further consideration, it is strongly recommended that preliminary designs be developed to better refine the constructability, performance, costs, and permitting requirements.
With regards to impervious cover, it is recommended that the Village of Arden target a maximum effective impervious cover of 11% for each drainage area. Effective impervious does not include pervious areas such as green roofs, pervious pavement, and decks with gaps between the boards, thus lowering effective impervious does not prevent residents from utilizing their landscapes similar to their current uses. It becomes a choice of materials instead of preventing roofs, pavements, or decks. This effective impervious

can be spread across watersheds such that one watershed that is able to achieve an effective impervious cover less than 11% can compensate for one that is unable to reach the 11% threshold. It is recommended that any trading between watersheds be done according to the stream receiving the runoff such that credits in watersheds draining to Naamans Creek should not be applied to a watershed draining to Perkins Run, or vice versa.

For future planning guidelines Arden can consider implementing limits on effective impervious surfaces for a given leasehold as an overlay or additional restriction to the current zoning and subdivision rules. These would be in addition to the current State of Delaware Sediment and Stormwater Regulations and attempt to address individual residential ‘lot’ (leasehold) improvements that are often not covered by the State regulations due to the small size of the ‘lot’. A maximum impervious cover for a ‘lot’ computed as effective impervious cover is commonly applied by municipalities within the surrounding region. When this ‘lot’ maximum is applied over the larger watershed that contains open space, forested areas, etc., the overall watershed’s impervious cover begins to approach a particular target value such as our recommended maximum impervious cover of 11%. This regulation can help to hold the line against future increases in stormwater runoff. Additional actions to reduce runoff can be to require all or some percentage of impervious surfaces to be changed to pervious systems at the time they are renovated. This approach chips away at the impervious surfaces already installed and reduces the demands on existing and future drainage systems. Changes to zoning regulations such as these require additional studies, working groups, and civic engagement and require significant effort beyond this Plan to arrive at appropriate guidelines for the Village of Arden.

Several outfall locations require attention and stabilization. Stabilization is recommended to take the form of natural stream restoration techniques such as log sills, boulder-based grade control structures, careful regrading of banks, and to include the elimination of invasive species and heavy planting with native herbaceous and woody plants. The scope of work varies according to the conditions at each outfall location needing attention. The outfall channel for watershed A is the easiest for volunteer or citizen actions. The channel erosion primarily impacts Sherwood Forest. The outfalls for watershed E should get expert design, although much of the work may be able to be performed by volunteers. Tree removal would require professional help. The swale leading through leaseholder land from drainage area F should get expert design and be performed by a combination of volunteers and contractors. Significant tree removal and stump/root removal along with modest excavation is required for this outfall swale. The degree of outfall restoration for watershed G will depend on the scale of BMP implementation, the channel stability after BMP implementation is likely to improve and should be monitored.

Drainage investments can be focused by the impacts on surrounding properties and structures in need of maintenance and replacement. An example would be adding / continuing concrete gutters to the south side of Mill Road where a surface drainage improvement can result in a significant decrease in runoff across leaseholder’s yards. Another example would be at the low point in Miller’s Road north of Hillside Road. A series of catch basins are located along this stretch of roadway. Several catch basins are in need of maintenance and/or replacement. These catch basins are also prone to clogging. Curbs on the east side of the roadway are low at certain driveways. Replacing/rebuilding the catch basins to provide an open throat at the back of them to reduce clogging and replacing driveway curb with full height roll curb can significantly improve the capture of runoff and reduce overflow onto downslope properties. Extreme events may still overwhelm the system, particularly with heavy leaf fall or frozen conditions, but nuisance flooding can be effectively addressed. The catch basin on Miller's Road, at the end of Mill Road should be improved with a throat to help accommodate the increase in flow this gutter will bring to Miller's Road.

Replacing catch basins with a form that includes the curb opening or throat, should be implemented on a broad scale within Arden. It is recommended that an engineering consultant be used to evaluate the current condition and recommend the reconstruction or replacement configuration for each catch basin to be replaced. Increasing the ability of catch basins to capture flow and reduce clogging will significantly reduce surface flows along the streets. Surface flow on streets and the saturated soil conditions below the streets due to poor drainage accelerates pavement failure. Improving the surface drainage system will lead to an increase in the longevity of the pavement systems. The more water there is in the pipes, the more force there will be at the point of outfall. These increased flows can result in an increase in erosion where the built infrastructure meets the natural landscape. When feasible drainage improvements should be implemented with any hydrologically connected BMPs. If costs or other constraints prohibit this more balanced approach and drainage infrastructure implemented prior to any BMPs, the outfall area should be carefully monitored for increased degradation.

ALPHABETICALLY BY WATERSHED

BMP	common land	meets WQ	meets 2YR or >	implementation complexity	cost by treatment	score	cost	effective impervious reduction	
	Y - N - M	Y - N - M	Y - N - M	H - M - L	H - M - L	sum	$0.00	percent	implementation complexity and miscellaneous notes
A1-bio	3	3	1	1	2	10	$ 87,750	3.1	this faciltiy requires additional gutters; revisions to existing catch basins; re-design of the intersection paving and the overflow is long but likely feasible to B1
B1-bio	2	3	1	2	2	10	$ 20,000	0.6	drainage infrastructure is present for this facility and likely able to be straight forward for modification; re-sizing and outfall revisions may be required to accept additional run-off from A-1
B2-swale	3	1	1	2	3	10	$ 10,000		implementation of a swale is generally inexpensive, this one may cost more if utlities or bedrock is encoutered; the overflow area is uknown but it seems potentially feasible to connect to the proposed BuzzWare system.
C1-bio	1	3	3	1	2	10	$ 59,550	0.6	no feasible overflow location was able to be identified
C2-porous paving	1	3	3	1	1	9	$ 36,950	0.2	no feasible overflow location was able to be identified but the small watershed may allow for surcharge
C3-bio	3	3	3	3	2	14	$329,500	0.8	this facility likely has a feasible draiange connection to The Highway system
C4-porous paving + bio	3	3	3	3	2	14	$155,050	1.4	this facility likely has a feasible draiange connection to The Highway system
C5-bio	2	3	1	3	2	11	$ 71,700	1.7	this facility likely has a feasible draiange connection to The Highway system
C6-bio	1	3	1	2	2	9	$ 32,700	1.7	the overflow connection is unclear and could be difficult but given this area already collects stormwater it may be feasible to design it for infiltration with further design investigations.

ALPHABETICALLY BY WATERSHED (continued)

BMP	common land	meets WQ	meets 2YR or >	implementation complexity	cost by treatment	score	cost	effective impervious reduction	
	Y - N - M	Y - N - M	Y - N - M	H - M - L	H - M - L	sum	$0.00	percent	implementation complexity and miscellaneous notes
C7-bio	1	3	3	3	2	12	$ 99,400	0.6	overflow conveyance appears feasible to the stream corridor across the street
C8-bio	3	3	3	2	2	13	$271,115	3.3	the area appears well suited for a facility but the area will need to be investigated for existing pipe networks and thus will add costs to the design
E1-porous paving	3	3	3	2	1	12	$ 73,800	1	if the design is able to utilize infitrative soils the draianage infrastructure should be low, if good soils are not availible and overflows are needed, the costs will be high as there is no nearby network
E2-bio	3	3	1	1	2	10	$ 20,000	0.7	this faciltiy requires additional gutters; re-design of the intersection paving with a valley gutter, and the slopes are steep and could prove difficult for any convayence connections to the downstream system
E3-bio	1	3	3	2	2	11	$186,000	1.4	this faciltiy requires the installation of gutters and brush clearing; overflow is likely feasible but this facility will benefit from a careful design to respond to existing patterns and maximize water quality treatement while providing safe conevyance.
F-stream	2	3	2	3	3	13	$265,500	161.2	complexities to this restoration would be access, neighbors, and the mature canopy
G1-porous paving	3	3	3	1	1	11	$ 76,900	1.7	the system between G1, G2, and G3 appears feasible with additional infrastructure costs need for the additional gutter and drainage network to get to Orleans Road and the narrow footprint to work within
G-2-bio	1	3	1	1	2	8	$ 20,000	2.5	
G-3-bio	1	3	1	1	2	8	$ 20,000	2.2	
G-4-detention	3	3	3	3	3	15	$ 97,300	16.8	access is likely the largest complexity of this location

ALPHABETICALLY BY WATERSHED (continued)

BMP	common land	meets WQ	meets 2YR or >	implementation complexity	cost by treatment	score	cost	effective impervious reduction	
	Y - N - M	Y - N - M	Y - N - M	H - M - L	H - M - L	sum	$0.00	percent	implementation complexity and miscellaneous notes
									Orleans Road and the narrow footprint to work within
G-2-bio	1	3	1	1	2	8	$ 20,000	2.5	
G-3-bio	1	3	1	1	2	8	$ 20,000	2.2	
G-4-detention	3	3	3	3	3	15	$ 97,300	16.8	access is likely the largest complexity of this location
H1-porous paving	3	3	3	3	1	13	$ 76,900	0.4	the facility is adjacent to open areas with multiple opportunties to connect the overflow; some trees adjacent to the area but they are unlikely to have significant root structures in the road footprint.
H2-bio	3	3	3	2	2	13	$202,000	1.7	curb cuts, gutters, and a valley gutter will need to be implemented to direct water to this garden; there is likely potential to connect this garden to the roadway drainage, which would add costs
H3-bio	3	3	3	2	2	13	$ 82,200	2	curb cuts, gutters, and a valley gutter will need to be implemented to capture road run-off and direct it to this garden; mature trees may add additional complexity to the facility modifications.
I1-planter	3	3	1	1	2	10	$ 55,900	1.5	the overflow connection is unclear and the area is a tight fit; although this is being illustrated on common land it may require additional use of leaseholder land
J1-porous paving	3	3	3	3	1	13	$ 33,225	0.7	this installation likely has minimal complexities with the location on common land directly next to a roadway, and an existing drainage nework downhill.
J2-bio	3	3	1	3	2	12	$ 55,800	15.7	this installation likely has minimal complexities with the location on common land directly next to a roadway, and an existing drainage nework downhill.

SORTED BY SCORE

BMP	common land	meets WQ	meets 2YR or >	implementation complexity	cost by treatment	score	cost	effective impervious reduction	
	Y - N - M	Y - N - M	Y - N - M	H - M - L	H - M - L	sum	$0.00	percent	implementation complexity and miscellaneous notes
G-4-detention	3	3	3	3	3	15	$ 97,300	16.8	access is likely the largest complexity of this location
C3-bio	3	3	3	3	2	14	$329,500	0.8	this facility likely has a feasible draiange connection to The Highway system
C4-porous paving + bio	3	3	3	3	2	14	$155,050	1.4	this facility likely has a feasible draiange connection to The Highway system
C8-bio	3	3	3	2	2	13	$271,115	3.3	the area appears well suited for a facility but the area will need to be investigated for existing pipe networks and thus will add costs to the design
F-stream	2	3	2	3	3	13	$265,500	161.2	complexities to this restoration would be access, neighbors, and the mature canopy
H1-porous paving	3	3	3	3	1	13	$ 76,900	0.4	the facility is adjacent to open areas with multiple opportunties to connect the overflow; some trees adjacent to the area but they are unlikely to have
H2-bio	3	3	3	2	2	13	$202,000	1.7	curb cuts, gutters, and a valley gutter will need to be implemented to direct water to this garden; there is likely potential to connect this garden to the roadway drainage, which would add costs
H3-bio	3	3	3	2	2	13	$ 82,200	2	curb cuts, gutters, and a valley gutter will need to be implemented to capture road run-off and direct it to this garden; mature trees may add additional complexity to the facility modifications.
J1-porous paving	3	3	3	3	1	13	$ 33,225	0.7	this installation likely has minimal complexities with the location on common land directly next to a roadway, and an existing drainage nework downhill.
C7-bio	1	3	3	3	2	12	$ 99,400	0.6	overflow conveyance appears feasible to the stream corridor across the street

SORTED BY SCORE (continued)

BMP	common land Y - N - M	meets WQ Y - N - M	meets 2YR or > Y - N - M	implementation complexity H - M - L	cost by treatment H - M - L	score sum	cost $0.00	effective impervious reduction percent	implementation complexity and miscellaneous notes
E1-porous paving	3	3	3	2	1	12	$ 73,800	1	if the design is able to utilize infitrative soils the draianage infrastructure should be low, if good soils are not availible and overflows are needed, the costs will be high as there is no nearby network
J2-bio	3	3	1	3	2	12	$ 55,800	15.7	this installation likely has minimal complexities with the location on common land directly next to a roadway, and an existing drainage nework downhill.
C5-bio	2	3	1	3	2	11	$ 71,700	1.7	this facility likely has a feasible draiange connection to The Highway system
E3-bio	1	3	3	2	2	11	$186,000	1.4	this faciltiy requires the installation of gutters and brush clearing; overflow is likely feasible but this facility will benefit from a careful design to respond to existing patterns and maximize water quality treatement while providing safe conevyance.
G1-porous paving	3	3	3	1	1	11	$ 76,900	1.7	the system between G1, G2, and G3 appears feasible with additional infrastructure costs need for the additional gutter and drainage network to get to Orleans Road and the narrow footprint to work within
A1-bio	3	3	1	1	2	10	$ 87,750	3.1	this faciltiy requires additional gutters; revisions to existing catch basins; re-design of the intersection paving and the overflow is long but likely feasible to B1
B1-bio	2	3	1	2	2	10	$ 20,000	0.6	drainage infrastructure is present for this facility and likely able to be straight forward for modification; re-sizing and outfall revisions may be required to accept additional run-off from A-1

SORTED BY SCORE (continued)

BMP	common land Y - N - M	meets WQ Y - N - M	meets 2YR or > Y - N - M	implementation complexity H - M - L	cost by treatment H - M - L	score sum	cost $0.00	effective impervious reduction percent	implementation complexity and miscellaneous notes
B2-swale	3	1	1	2	3	10	$ 10,000		implementation of a swale is generally inexpensive, this one may cost more if utlities or bedrock is encoutered; the overflow area is uknown but it seems potentially feasible to connect to the proposed BuzzWare system.
C1-bio	1	3	3	1	2	10	$ 59,550	0.6	no feasible overflow location was able to be identified
E2-bio	3	3	1	1	2	10	$ 20,000	0.7	this faciltiy requires additional gutters; re-design of the intersection paving with a valley gutter, and the slopes are steep and could prove difficult for any convayence connections to the downstream system
I1-planter	3	3	1	1	2	10	$ 55,900	1.5	the overflow connection is unclear and the area is a tight fit; although this is being illustrated on common land it may require additional use of
C2-porous paving	1	3	3	1	1	9	$ 36,950	0.2	no feasible overflow location was able to be identified but the small watershed may allow for surcharge
C6-bio	1	3	1	2	2	9	$ 32,700	1.7	the overflow connection is unclear and could be difficult but given this area already collects stormwater it may be feasible to design it for infiltration with further design investigations.
G-2-bio	1	3	1	1	2	8	$ 20,000	2.5	the system between G1, G2, and G3 appears feasible with additional infrastructure costs need for the additional gutter and drainage network to get to Orleans Road and the narrow footprint to work within
G-3-bio	1	3	1	1	2	8	$ 20,000	2.2	the system between G1, G2, and G3 appears feasible with additional infrastructure costs need for the additional gutter and drainage network to get to Orleans Road and the narrow footprint to work within